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THE KIDNEY PELVIS

A FURTHER CONTRIBUTION TO ITS PHYSIOLOGY AND PATHOLOGY

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IN previous communications, the author has drawn attention to the normal physiology of the kidney pelvis and to the value of pyeloscopy and pyelometry in the clinical investigations of the pathological kidney, and in determining the etiology of "kidney pain."

The author would, in the first place, like to express his deep regret that reference was not made in these papers to the pioneer work of Willis Manges in 1912. This work was quite unknown to him until his attention was recently drawn to the fact by a colleague. The author would like to state that he in no way attempted in his communications to lay claim to any priority in this work as in his communications he made reference to the fact that he had been attracted to this line of investigation by the work of French observers in 1926–7.

In the present communication an attempt will be made to collate briefly the results obtained by pyeloscopy and pyelometry in about 100 patients with the clinical symptoms and the pathological findings as disclosed by other methods of investigation, where such have been obtained, and to illustrate various types. All the cases illustrated are women.

TECHNIQUE

The ureter was first catheterized, as large a catheter, preferably No. 7 or 8 Charriere, as would pass being used. The kidney pelvis (in the earlier cases) was then filled with the radio-opaque material, and pyeloscopy was performed, and the tracing obtained (pyelometry). The pelvis was then refilled with the radio-opaque material and a pyelogram obtained. In the later cases (the majority) the technique was simplified in that the tracing was obtained first, the kidney pelvis was then filled under vision, its capacity determined, the contractions of the calyces and body of the pelvis ("ventricle") studied, and the passage of the "globule" down the ureter observed. A pyelogram was taken with the catheter still in the ureter. The catheter was then withdrawn and another picture was taken immediately. In regard to the method of obtaining the graphic record of contractions of the kidney pelvis and variations of the intrapelvic pressure, the technique followed in this investigation has been similar to that previously described (Jona and Flecker) except that advantage has been taken of a trick of technique adopted by Trattner in his work on ureterography in which he injects fluid into the ureter to determine its capacity and to induce expulsive contractions. It was found, however, that injecting the fluid with a hypodermic or serum syringe often involved the use of a great deal more pressure into the pelvis than was good for the patient judging by the

painful response evoked. The apparatus was therefore slightly modified by connecting the reservoir via a T piece and a stop cock with a burette the height of which above the patient could be adjusted and the water run into the pelvis at a pressure of 30 to 50 centimeter water pressure from the burette and immediately stopped when the patient complained of pain.

RESULTS

It would not be out of place first to refer to an interesting phenomenon observed in many pyelograms of a class of patients who suffered from chronic "kidney pain" and in whom filling of the kidney pelvis was accompanied by great and often persistent pain comparable with the pain for which she was seeking relief. In the class of patients referred to, the capacity of the pelvis as indicated by the amount of contrast fluid which could be injected before this pain was elicited was generally 2 to 5 cubic centimeters, and it was found that the pyelograms invariably showed filling of the collecting tubules and injection of the "kidney substance" (Fig. 1). Pyeloscopy and the pyelogram in these cases showed a condition of spasm of the calyces and of the body of the pelvis ("ventricle") accompanied by relaxation of the communicating channels and also of the ureter in its upper two-thirds although there was generally some spasm in the ureter in its lower part. When the calyces contracted the contrast material used for the pyeloscopy and pyelogram generally passed readily into the body of the pelvis and the globule formed in the upper ureter was passed readily down the ureter to the region of spasm where it was temporarily held up and then passed on into the bladder. The author considers that this hold-up is responsible for the patient's kidney pain. The urine produced by the secreting apparatus of the kidney is passed into the collecting tubules but cannot enter the calyces on account of their spasm and is thus dammed

Fig. 1.

Fig. 2.

Fig. 2.

Fig. 1. Pyelogram. Filling of collecting tubules, dilatation of communicating channels and upper part of ureter, spasm of calyces and "ventricle."

Fig. 2. Pyelogram. Spasm of pelvis, capacity 3 cubic centimeters. Gall bladder contained a large laminated stone (see also Fig. 3).

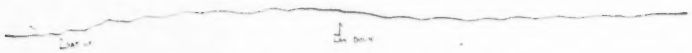

Fig. 3. Catheter stopped at about 3 centimeters from pelvis at spasm in ureter in relation to a slight kink in the ureter. All calyces contracted well but apparently in a condition of spasm. Capacity of pelvis 3 cubic centimeters. Vomited bile on injecting fluid into kidney pelvis. Hold-up of globule at 3 centimeters from pelvis in region of tip of catheter and occasional antiperistalsis. Pyelogram also shows apparently laminated stone in relation to upper pole of kidney. Cholecystography confirms presence of stone in gall bladder. Cholecystectomy. Relief.

ack into the collecting tubules and pain re-ults. If the author's suggestion that there is normal "maintenance filling" of the calyces nd pelvis (Jona, 1) is accepted, then one ight say that in these cases on account of ne condition of spasm in the calyces and elvis there is no (or diminished) mainte-ance filling of the pelvis or calyces. Thus any esistance to outflow from the ureter (either y spasm in the ureter or temporary obstruc-on or kinking by some extraneous cause) will immediately result in damming back of urine irectly into the kidney tubule system with nsation of pain and impairment of secretory ctivity. Whether the dilatation of upper reter, communicating channels, and collect-ng tubules associated with spasm of the inter-vening "ventricle" of the pelvis and the calyces is the result of a reciprocal innervation such as one would expect to exist between a sphincter (or a duct) apparatus and a detrusor apparatus, respectively, cannot be stated, but this would be a more satisfactory explanation than mechanical dilatation due to back pres-sure. The causation of this condition of spasm is often difficult to elucidate but in most cases it could be attributed to some pathological condition in an overlying viscus such as the colon or appendix or a viscus with related innervation such as ovary, fallopian tubes, gall bladder, or appendix or some pathological condition in the cellular tissue in relation to the ureter, generally the result of some previous operation or inflammation. Thus a pathological appendix or gall bladder might be the cause of a spasm of the right ureter, pathological ovary or tubes the cause of spasm of the corresponding ureter, and not uncommonly spasm of the ureter was found in the region of the brim of the pelvis or be-tween this part and the urinary bladder where one might readily understand thickening and inelasticity of the pelvic cellular tissue after operations on, or inflammation of, the pelvic viscera. Figure 2 shows the pyelogram and Figure 3 the tracing in a patient who com-plained of pain referable to the right kidney. This patient was very tender in the right costovertebral angle. When the kidney pelvis was filled to capacity (3 cubic centimeters), she complained that the pain that she felt was

Fig. 4. Pyelogram showing sluggishly contracting small pelvis, distended capacity 6 cubic centimeters. Chole-cystography negative. Appendix removed some years ago. Has been well since taking quinine and eserine.

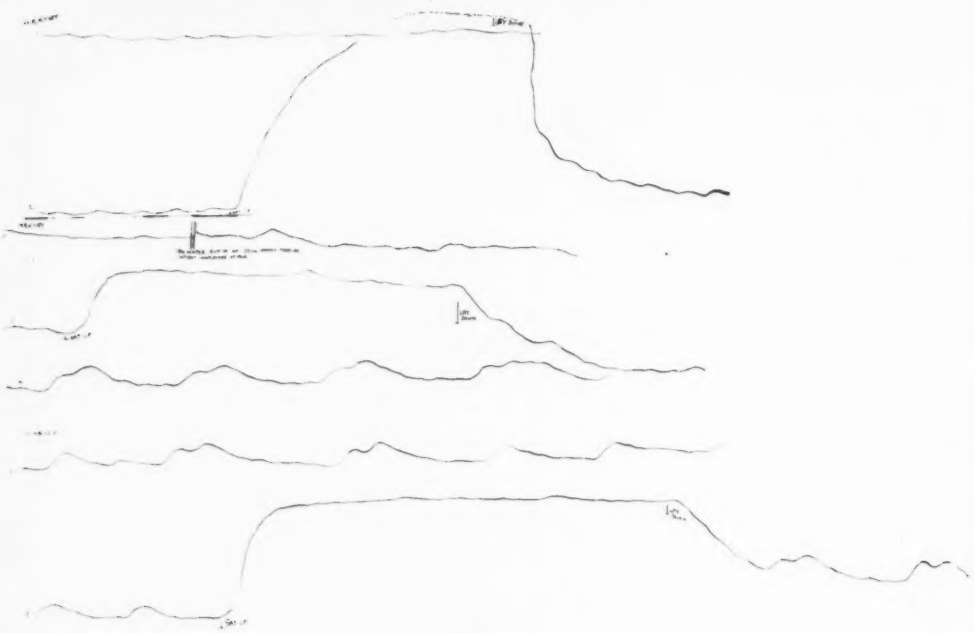

Fig. 5.

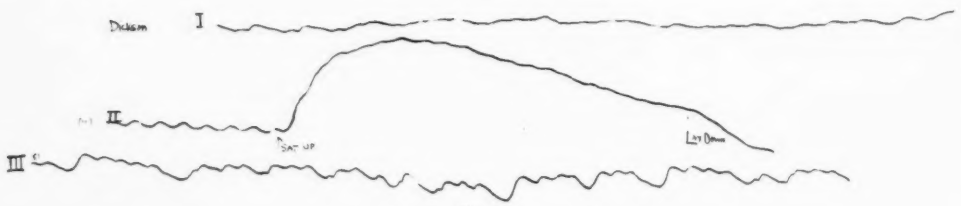

Fig. 6.

Fig. 5. Appendicectomy 15 years ago. Patient has complained of pain in right loin for 4 years. Sluggishly contracting small pelvis, distended capacity 6 cubic centimeters. Vomited bile stained fluid immediately after filling pelvis. Cholecystography negative (see also Fig. 4).

Fig. 6. Sluggishly contracting pelvis with very slow movement of globule down ureter. There is apparent spasm at about 10 centimeters from the kidney and occasional antiperistalsis along the ureter. The kidney is ptosed.

what she usually felt, and she vomited green bile. The pyelogram also shows a large calculus in the gall bladder (confirmed by cholecystography). Cholecystectomy was performed and she has been quite free of her pain and "bilious attacks" since. Patients of this type with spasm of the pelvis of the right kidney also almost invariably vomit when the kidney pelvis is rapidly filled (for example, when the contrast fluid is injected for the taking of the pyelogram) and the vomitus is generally bile stained, an indication of excessive regurgitation of bile into the stomach and of antiperistalsis in this viscus. These patients will often volunteer the information that when the pain for which they are seeking relief comes on they vomit. This vomiting reflex is not an uncommon symptom of spasm in any hollow viscus unable to expel its contents, such as gall bladder or appendix. When the condition is on the right side and is associated with a diseased gall bladder, the pain disappears after cholecystectomy. In cases in which spasm is not apparently associated with

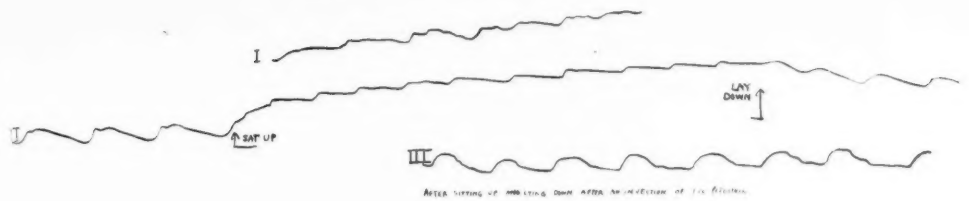

Fig. 7.

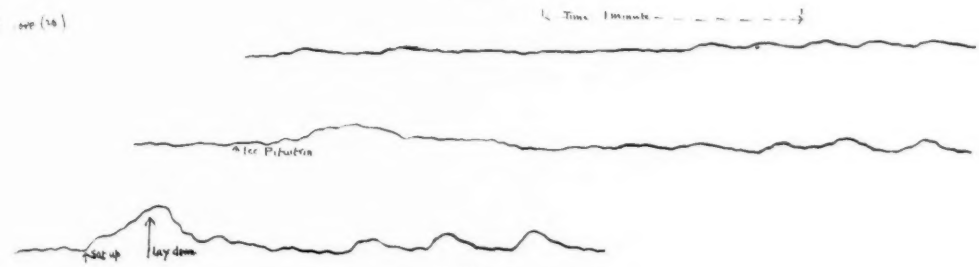

Fig. 8.

Fig. 7. Sluggishly contracting calyces and as each calyx contracts it empties through dilated communicating channel direct through pelvis into ureter.

Fig. 8. Actively contracting slight hydronephrosis; 16 cubic centimeters fluid injected into pelvis without pain. Catheter held up about 4 centimeters from kidney by kink in ureter above which ureter was atonic. (Patient has large subinvoluted uterus.) The dilated pelvis and ureter can be regarded as a failure of these parts to involute from the enlarged condition which is normally found in the presence of pregnancy to the normal non-pregnant size.

a diseased gall bladder as when a normal Graham's test is obtained, the patients very often respond readily to such a drug as quinine and after a course of treatment for a few weeks often remain apparently cured, but even in these cases one cannot help feeling that when no pathological condition in the urinary tract is demonstrable a pathological condition in a related viscus is the cause and should be sought for. This is illustrated in the pyelogram (Fig. 4) and tracing (Fig. 5).

Another interesting case is illustrated by the patient whose pyelogram (Fig. 24) is shown.

This patient has had several attacks of hæmaturia and pain in the right loin. Radiological examination of the urinary tract was negative. The urine contained pus and blood cells. Pyeloscopy showed spasm of the kidney pelvis and upper ureter as far as the brim of the pelvis. Cholecystography was done and the report was "pathological gall bladder." At operation a diseased gall bladder containing several small stones and a diseased appendix were found. The gall bladder and appendix were removed and the patient has been well since. It is suggested that in this case the kidney pelvis was infected across the peritoneal cavity from the infected gall bladder, thus accounting for the bacilluria and occasional hæmaturia.

In the present analysis an attempt will be made to present tracings and pyelograms illustrating most of the following pathological variations of the normal physiology of the kidney pelvis.

1. Normal tracing. Calyces and pelvis contract normally and globule passes normally down ureter; capacity of pelvis about 10 cubic centimeters (Fig. 6, III; Fig. 7, III).

2. Atony of pelvis. (a) Calyces and pelvis contract poorly when pelvis is filled; capacity about 15 to 25 cubic centimeters (Figs. 8, 9, 10, 15, 21). (b) Calyces and pelvis contract well when only about 3 to 5 cubic centimeters of fluid is in pelvis. This is seen in tracing Figure 11 after patient has sat up, when kidney pelvis partly empties itself. When the pelvis is apparently quite empty (after the patient has sat up for some time) the contractions are shallower. In these cases the tracing shows very shallow waves due to poor

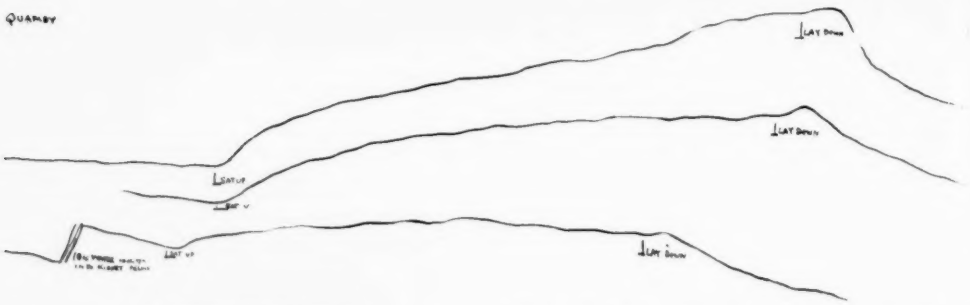

Fig. 9. Sluggishly contracting slight hydronephrosis (capacity of pelvis about 15 cubic centimeters). Some hold-up in ureter at brim ("vagotonic" slow pulse, 60; contracted pupils). Operation for retroverted uterus (Gilliam operation) and chronic appendix (appendicectomy performed). Patient also had ptosed cæcum, colon in pelvis, and spastic transverse colon.

Fig. 10. Pyelogram. Sluggishly contracting slight hydronephrosis. Capacity of pelvis 15 cubic centimeters (see also Fig. 9).

contractions. When the patient is made to sit up some of the fluid is expelled from the pelvis by the rise in intrapelvic pressure induced and the waves are increased in amplitude (see also Fig. 13, I and II. Fig. 13, III, shows the effect of overfilling the kidney pelvis and Fig. 13, IV, the improvement in rhythm (abolition of antiperistalsis) by emptying of the kidney pelvis by sitting up and lying down several times). The tone of this class of pelvis can be improved by giving stimulating drugs such as eserine or strychnine in ordinary therapeutic doses over a period of one month or more, or an occasional injection of pituitrin (Fig. 8).

3. Spasm of the pelvis. Capacity of the pelvis about 3 to 5 cubic centimeters (1) without any apparent antiperistalsis in the ureter, (2) with antiperistalsis in the ureter. Shallow waves are seen which are not improved as a rule by sitting up. However, if the pelvis is overdistended the waves improve when patient sits up (Fig. 20, II). When antiperistalsis occurs these waves of antiperistalsis are superimposed on the waves of the calycal and pelvic contractions and so an irregular series of waves is produced. Occasionally the sudden distention of a small pelvis apparently stimulates its musculature and an improved series of waves is obtained (Fig. 20, III, IV). The spasm in these cases can be relieved by giving quinine sulphate or hydrochloride, say 5 grains, three times a day. If the kidney pelvis is contracting too rapidly the condition can be relieved by aceto-salicylic acid.

4. Spasm in the ureter (1) without apparent antiperistalsis, (2) with antiperistalsis in the ureter—(a) up part of the ureter, (b) up to pelvi-ureteral junction, (c) in to pelvis (se

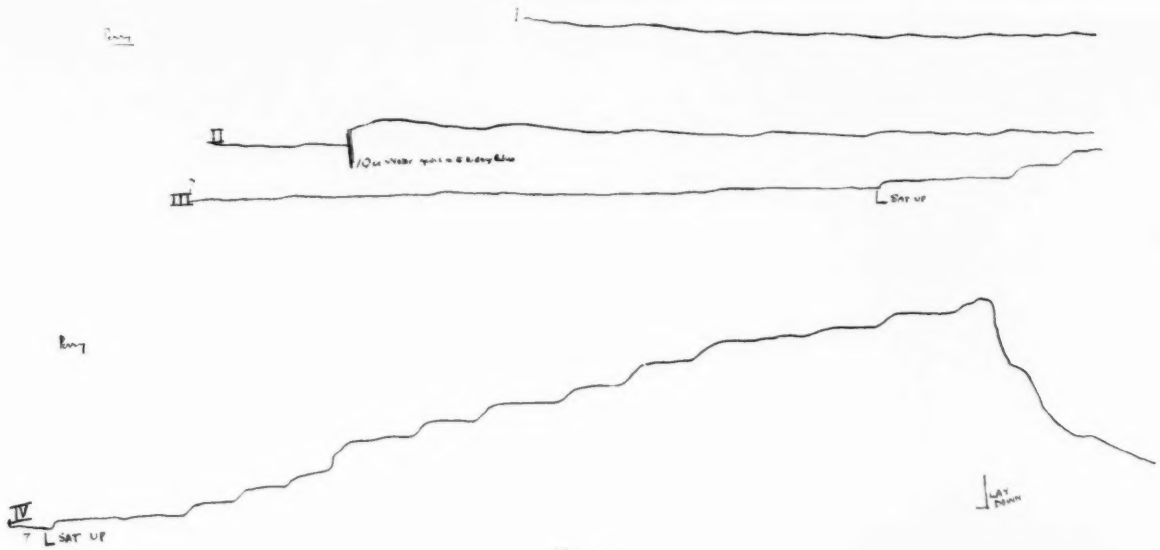

Fig. 11.

Fig. 12.

Fig. 11. Sluggishly contracting dilated kidney pelvis (see also Fig. 12).
Fig. 12. Pyelogram. Sluggishly contracting dilated kidney pelvis. In this case an intravenous pyelogram gave a very poor small shadow apparently due to impaired excretory activity of the kidney (see also Fig. 11).

Fig. 13.

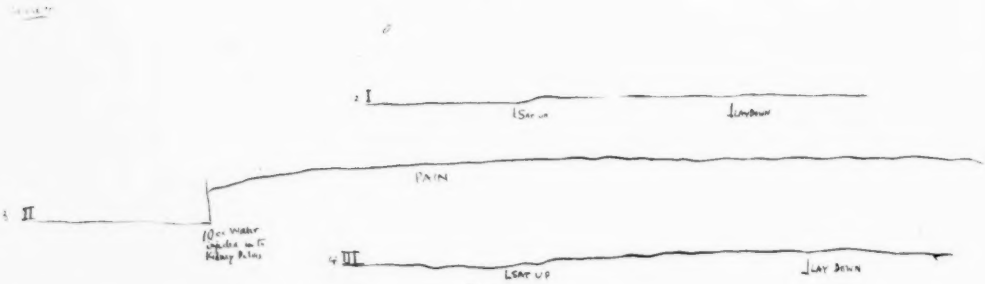

Fig. 14.

Fig. 13. Sluggishly contracting slight hydronephrosis. Spasm in ureter at brim with antiperistalsis up to pelvi-ureteral junction. Appendicectomy. Relief.

Fig. 14. Pyeloscopy. Capacity of pelvis 4 cubic centimeters. Spasm of whole pelvis but relaxed upper long communicating channel. Spasm in ureter at brim with antiperistalsis in ureter, sometimes to upper calyx. Pyelogram shows filling of collecting tubules. Tracing 3 and 4.

Fig. 13, III; Fig. 17; Fig. 20), (d) in to a calyx (Fig. 14).

If no antiperistalsis occurs the pressure in the pelvis steadily mounts until the waves of contraction pass through; if there is antiperistalsis, arrhythmia is produced. In the latter case the pressure in the pelvis is low and there is very little rise in pressure when patient sits up. The pain in these cases is best relieved by an injection of pituitary extract, and with the restoration of normal function it is remarkable how long it will remain apparently normal—at any rate the patient feels well. One such case was illustrated in a previous paper (Jona, 7).

5. Atony or dilatation of upper ureter. Greatly lowered resistance to outflow from kidney pelvis. Shallow waves shown with very small rise in intrapelvic pressure after patient sits up or lies down or after the injection of fluid into the kidney pelvis (Figs. 22, 23). These patients are best relieved by giving eserine and in cases in which there is an associated spasm of the kidney pelvis quinine is given with eserine.

6. Arrhythmia accompanied by pain. When the arrhythmia is abolished, tracing shows regular contractions and the patient's pain is relieved (Fig. 6, III; Fig. 25; Fig. 26).

The patients, however, do not readily fall into one or other of these groups but one often finds combinations of the various groups and in cases one may find spasm in one part of the system and relaxation in another. Where some definite pathology of some related viscus can be determined it is easy enough to understand the basis of the dysfunction of the pelvi-ureteric musculature but in case no definite lesion is demonstrable search must be made for the cause in the kidney itself, in some pathological condition in the urine such as phosphate or uric acid crystals, or in some disturbance of the pelvi-ureteral musculature itself or its nerve supply. In this latter regard the physiological information is rather vague. Many of these patients are of "neurotic" type

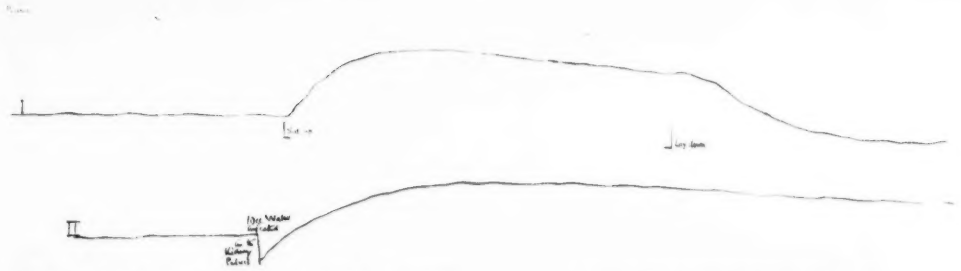

Fig. 15. Dilated right kidney pelvis with sluggishly ntracting calyces and pelvis. Globule passed quickly wn ureter (see also Fig. 16).

We know that in the dog (Starling) the idney receives nerves from the fourth dorsal the second lumbar segments via the sym- athetic chain through the renal plexus. Many, if not most, of these nerves are un- oubtedly vasomotor, but some must be ef- erents to the smooth muscle of the renal elvis and the ureter. Whether some of these re also afferents has not to my knowledge een definitely determined, and it would also e interesting to know definitely what happens to the branch of the vagus to the renal plexus described by anatomists (Cunningham, 2) and whether this twig contains afferents or effer- ents or both. In regard to other viscera the gall bladder is supplied from the left vagus and solar plexus (Cunningham, 3), the ovary from the tenth dorsal nerve, the fallopian tubes from eleventh and twelfth dorsal and first lumbar segments (Cunningham, 6), and the appendix from solar plexus and possibly also the vagus. The kidney, however, is appar- ently able to function and its musculature can carry out its function when all nerves have apparently been cut as has been done by va- rious surgeons in the operation of so called renal sympathectomy. This fact is also de- monstrable in the isolated kidney. One has also seen patients in whom a pathological gall bladder has been associated with dysfunction in the left kidney pelvis and the patient has had relief of her kidney pain after cholecys- tectomy. That marked reflex effects may be set up from the kidney is also well known and in the class of case referred to above where one finds by pyeloscopy spasm of the kidney this is common. In such a case, in which the pelvis

Fig. 16. Pyelogram. Dilated kidney pelvis with slug- gishly contracting calyces and "ventricle" (see also Fig. 15).

is rapidly filled, the patient complains of great pain and often vomits (the vomitus often being bile stained), the pulse is slowed, and the patient becomes pale and "knocked out." Such a case is illustrated in Figure 9. At operation this patient was found to possess a chronically inflamed appendix with a ptosed ascending colon and cæcum, spastic trans- verse colon, and retroverted uterus. She has been well since operation (removal of appen- dix and correction of retroversion) but what her kidney pelvis is like now the author can- not say because the patient declines further

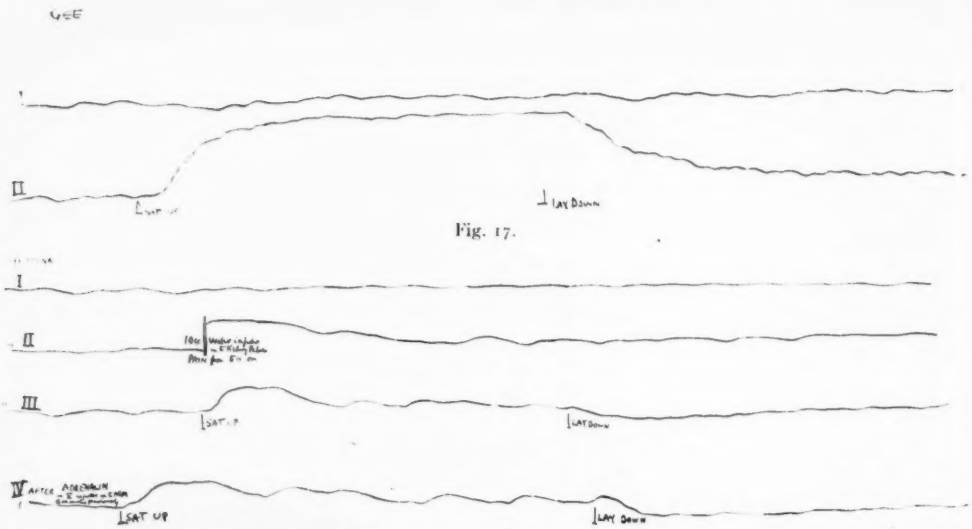

Fig. 17.

18.

Fig. 17. Pelvis and calyces contracting regularly. Antiperistalsis in ureter from near brim back into pelvis at irregular intervals with occasional stasis of globule in ureter.

Fig. 18. Capacity of pelvis 4 cubic centimeters, all calyces filled and contracting feebly. Globule in ureter passed down to 10 centimeters readily and held up in a section of ureter 10 to 18 centimeters from pelvis and again at brim; antiperistalsis in these sections. Pyelogram shows small calyces and apparent atony of all communicating channels with filling of collecting tubules of kidney (see also Fig. 19).

Fig. 19. Pyelogram. Capacity of pelvis 4 cubic centimeters. Spasm at calyces and atony of all communicating channels and filling of collecting tubules of kidney (see also Fig. 18).

investigation as she feels quite well. Another important aspect of the subject which must also determine our interpretation of the effects obtained is the apparent difference in the pictures sometimes obtained by intravenous and retrograde pyelography. Such a case is illustrated by Figure 12. The pyelogram obtained by intravenous pyelography shows an apparently normal sized and very poorly filled pelvis whereas by the retrograde method an obvious hydronephrosis with "rounding of the calyces" is demonstrated. The author thinks that in this case there was impaired excretion by the kidney (this is supported by the poor shadow in the intravenous pyelogram compared with the shadow of the opposite kidney) and that the patient's pain only came on under conditions when the outflow of urine from the kidney was impaired and the pelvis became distended.

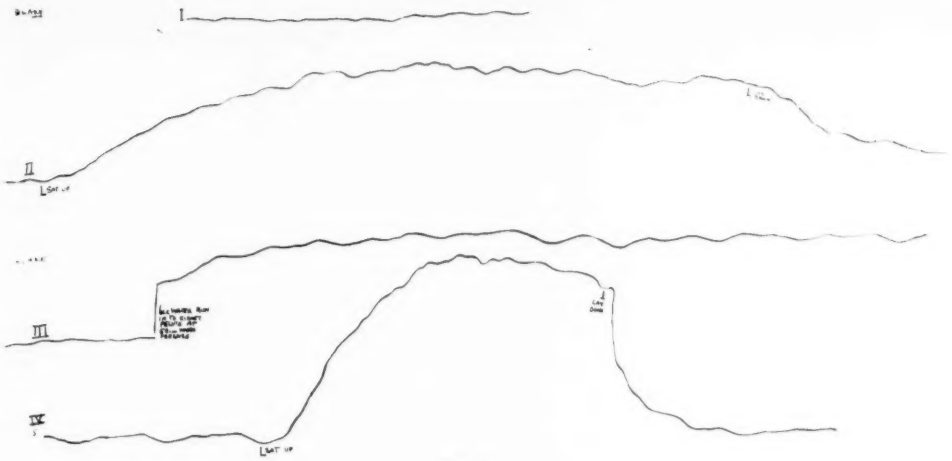

Fig. 20.

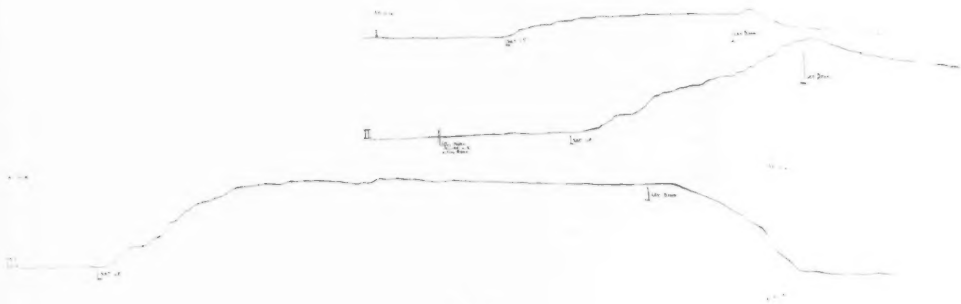

Fig. 21.

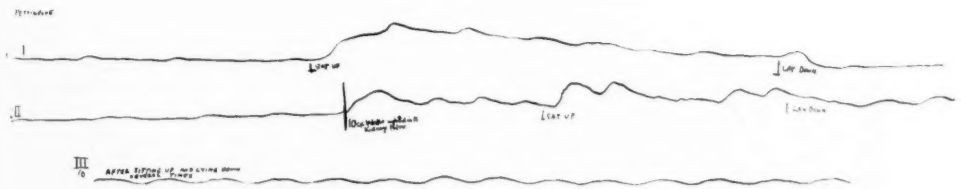

Fig. 22.

Fig. 20. Capacity of pelvis 6 cubic centimeters. Spasm in pelvis. Poorly contracting calyces, spasm in ureter at brim with antiperistalsis up to pelvis and sometimes into "ventricle."

Fig. 21. Some atony of pelvis and upper ureter. "Terebril" apparently ran down ureter as fast as it was run into the pelvis. Cholecystography: "pathological gall bladder." Operation hydrops of gall bladder which contained 200 cubic centimeters "white bile." Numerous stones, 32, about 1 centimeter in diameter removed and also one impacted in cystic duct.

Fig. 22. All calyces contracted well. Hold-up in ureter 5 centimeters from pelvis with some antiperistalsis in this section of the ureter but globule passed well down ureter and pelvis emptied readily. Capacity of pelvis 10 cubic centimeters. Slight dilatation of upper ureter as far as brim where spasm of ureter (? due to old retroperitoneal infection. Appendicectomy several years ago.) (See Fig. 23.)

Fig. 23.

Fig. 24.

Fig. 23. Pyelogram. Capacity of pelvis 10 cubic centimeters. Slightly dilated upper ureter as far as brim where spasm of ureter? due to old retroperitoneal infection (appendicectomy several years ago.) (See also Fig. 22.)

Fig. 24. Pyelogram. Patient had recurrent hæmaturia and bacilluria. Spasm of kidney pelvis, and of ureter at the brim, with antiperistalsis. Gall bladder contained stones. Appendix pathological.

The occurrence of antiperistalsis in the ureter was so frequent that one wonders whether this may not be a pathological exaggeration of a normal occurrence—that is to say, that under certain normal conditions antiperistalsis does occur and that under certain pathological conditions it is exaggerated. We do know that antiperistalsis is a normal condition in the colon and facilitates the absorption of water from the bowel. May not stasis with antiperistalsis in the kidney duct system in the same way determine a physiological back-working in to the tubule system of the kidney and thus facilitate absorption of water in the tubules? It was found that antiperistalsis in the ureter is more commonly seen when the urinary bladder was full than when it was emptied prior to the pyeloscopy.

Fig. 25. Irregular contractions. Regular after pituitrin.

Fig. 26. Irregular contraction. Regular after pituitrin.

This point requires further investigation which will be much facilitated when it will be possible to observe the contractions of the kidney pelvis and the passage of the "globule" down the ureter without the necessity for the introduction of a ureteric catheter which introduces a foreign (and sometimes disturbing) element into the investigation. There can be little doubt that the inlying catheter must tend to induce spasm of the ureter, but it is suggested that this only mirrors (perhaps to an exaggerated degree) what normally occurs in the patient.

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EXPERIMENTAL CHRONIC INTESTINAL OBSTRUCTION FROM BLIND LOOPS

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DURING the last decade experimental studies on intestinal obstruction have resulted in a better understanding of the part played by distention, dehydration, demineralization, and loss of normal secretion in causing death. This appreciation has been reflected in clinical practice. Efforts are made to conserve the intestinal contents rather than to drain off the "toxic poisons" by indiscriminate enterostomy. This has led to the use in selected cases of entero-enterostomy for internal drainage of intestinal obstruction when removal of the obstructing agent is inadvisable or impossible. The fæcal stream is short-circuited above the obstruction. This leaves an inactive segment of intestine between the anastomosis and the point of constriction. The present study was made to determine what happened to this portion of the bowel.

METHODS

The experiments were conducted on dogs operated upon under conditions of surgical anæsthesia and asepsis. After the abdomen was opened, a point 12 inches below the duodenojejunal junction was determined and marked with a silk stitch. From this point, loops of intestine varying in length from 6 inches to 6 feet were measured. The distal point was marked, brought beside the proximal one, and the lumen joined by an anastomosis. The anastomosis was varied in two ways. In some the two limbs of the loop were placed side by side and united to create an antiperistaltic anastomosis. In others the distal limb was rotated 180 degrees to form an isoperistaltic anastomosis. The loop was obstructed by section of the bowel and inversion of the ends. The closed ends were tied or sutured together to prevent intussusception. The loop was obstructed in the proximal limb just beyond the anastomosis, at the middle point of the loop or in the distal limb just before the anastomosis (Fig. 1). This gave various lengths of bowel segments both on the proximal and the distal side of the obstruction. For the sake of comparison in a few animals the loop was created and anastomosed but not obstructed.

After data were collected on these preliminary experiments, it was found that the segment above the obstruction, between it and the anastomosis, dilated and caused trouble. Consequently a second series of experiments was done to study these blind proximal loops. In it the bowel was measured as before but after obstruction by transection, the distal end was brought up and anastomosed at the point from which the measurement was started. These anastomoses were ordinarily isoperistaltic but a few were antiperistaltic or end to side. In one group of animals, blind loops were created in the terminal ileum. Here the bowel was transected and obstructed at a point 6 inches from the ileocæcal valve. The length of loop was then measured up the ileum and the anastomosis made at the desired point with the distal stump.

After operation the animals were fed a liquid diet for 2 days, then gradually returned to their usual ration of table scraps mixed with bread. They were observed frequently for signs of anorexia, vomiting, diarrhœa, loss of weight, or lassitude. Samples of blood were obtained for chemical analysis. In case of death a complete postmortem examination was made with particular attention paid to the gastro-intestinal tract.

The blood examination included non-protein nitrogen, chlorides, carbon dioxide combining power, hæmoglobin, and occasionally blood sugar or blood volume determinations were added. The non-protein nitrogen was determined on whole blood by the method of Folin and Wu; chlorides and carbon dioxide by the Van Slyke method; hæmoglobin by the method of Robscheit; and blood volume by method of Hooper, Smith, Belt, Whippl

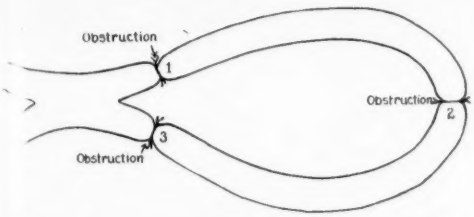

Fig. 1. A diagrammatic illustration of the method used in the preliminary experiments. A loop of intestine is joined by anastomosis to short circuit the fæcal stream. Obstruction at *1* gives a long segment distal to the obstruction in which the peristaltic wave is directed away from the blind end. Obstruction at point *2* gives equal sized proximal and distal loops. Obstruction at point *3* creates a long blind loop proximal to the point of block in which the peristaltic wave is toward the blind end. It is in this type that material is trapped in the blind loop.

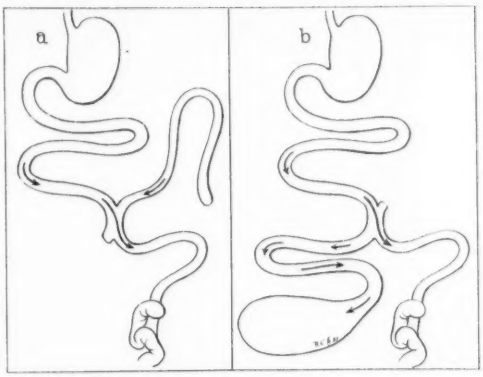

Fig. 2. a, A diagrammatic representation of a blind segment in which peristalsis empties the loop. In practice the two cut ends were tied together to prevent intussusception. b, Represents the opposite condition in which the material is carried into the blind loop by the direction of the peristaltic wave thus causing a trap for the accumulation of intestinal contents.

RESULTS

In all, 60 dogs were operated upon. Thirteen of these were discarded from consideration for various reasons. Two died of distemper; 2 died from acute intestinal obstruction, 1 because of torsion of the mesentery and the other from herniation of bowel through a rent in the mesentery. Three developed peritonitis soon after operation. All had a leak in a suture line, 1 at the anastomosis, the 2 others from the invaginated end of the severed bowel. Six animals died from intussusception. These all occurred in the preliminary experiments in which inadequate care was exercised to suture or tie together firmly the two ends of the severed bowel. Intussusception never occurred in the proximal segment. To do so it would have to go against the direction of the peristaltic wave. Consequently in later experiments designed to study the effect of blind loops having the fæcal stream carried into them, it was not necessary to guard against intussusception. But in cases in which the direction of the peristalsis is from the blind end toward the anastomosis, intussusception will regularly occur unless prevented by fixation from suture or adhesions. In 7 animals, loops up to 5 feet in length were joined by an anastomosis but were not obstructed. They were desired for comparison with the obstructed loops. After many months they showed no significant alteration from the normal. One interesting fact was noted that the anastomosis often persisted. In one instance it was patent 1 year after operation. This observation is contrary to the conception that an abnormal opening in an unobstructed viscus will close.

The fate of blind loops distal to the obstruction. When the direction of the peristaltic current is away from the blind end and toward the anastomosis (Fig. 2, a), the segment of intestine remains empty. If any material gets into this portion of the bowel it is promptly removed. In 8 animals, loops of 1, 2, 3, and 4 feet in length were created in the jejunum. The dogs were observed for 3 to 6 months. The appearance, activity, nutrition, appetite, and bowel function of these animals was normal. The blind loop when examined at operation or postmortem was collapsed and empty. Both gross and microscopic examination of the intestinal wall showed no abnormality. It may be concluded that moderate sized blind loops below the obstruction are harmless. Peristalsis tends to empty the lumen since it is directed away from the blind end. This type of loop is a functionless segment of bowel.

The effect of blind loops proximal to the obstruction. When the direction of peristalsis is toward the blind end, material is trapped in the loop of bowel (Fig. 2, b). It is carried in but can not get out. This results in the collection of intestinal contents with dilatation

Fig. 3. The size of a blind loop 102 days after its formation in comparison to the size of the normal intestine. Tremendous hypertrophy and dilatation has occurred.

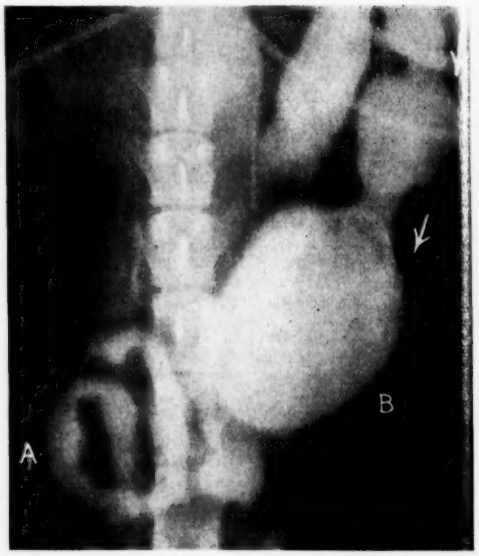

Fig. 4. Roentgenogram of a dilated blind loop. The arrows show powerful peristaltic waves driving the barium into the dilated end. Contrast the size of the blind loop, *B*, with the normal intestine, *A*.

of the intestine to form a veritable cesspool of the loop. It is a study of these animals that has been of the greatest interest in the present investigation.

There were 31 dogs with proximal blind loops that were suitable for study. In a consideration of the results, these may best be grouped into those with short, medium, and long jejunal loops and those with an ileal segment.

Short jejunal loops. Six dogs were studied with short blind loops in the upper jejunum.

Dog 31-109 had a loop 6 inches long. During his period of observation of 16 months there were no signs or symptoms of abnormality. At autopsy the loop was small, collapsed, and empty. It measured only 4 inches in length. Dog 31-232 had a 9 inch loop which caused no trouble. At the end of 15 months it was inspected and found to be 5 inches long, collapsed, and empty. Dog 31-310 had a 12 inch loop which after 12 months presented the same result. Thus blind loops of 1 foot or less in length caused no harm to the animal. They apparently emptied themselves.

Three animals were observed with 2 foot blind jejunal loops. One of these lived for 8 months without evidence of abnormality. It was found on inspection that the loop was dilated and filled with a thick cheesy material. In the 2 others perforation of the bowel and peritonitis caused death; in one instance in 42 days and in the other 154 days after operation. Both showed a large dilated blind loop filled with food and foreign material. The bowel had been ulcerated through by a piece of bone in one dog and perforated by a splinter in the other. Neither of these animals showed systemic change prior to the perforation.

Medium sized jejunal loops. The animals which had medium sized blind loops were the most interesting of the series. There were 10 in all, 6 with 3 foot loops and 4 with loops 4 feet in length.

Of the 6 with 3 foot loops, 1 died in 201 days from perforation of the bowel and peritonitis, 2 were sacrificed in 158 days and 222 days, respectively, and 3 died in 148, 174,

and 201 days after operation from the effects of the blind loop. Of the 4 animals with 4 foot loops, 1 died in 170 days from perforation, 1 died in 102 days from the effect of the loop, and 2 became quite toxic but were saved from death by the resection of the loop on the one hundred and sixty-sixth and two hundred and twenty-first days, respectively. Thus there were 6 dogs in this group which developed deleterious effects of the dilated blind loops. These animals all reacted alike. They were perfectly well for 2 to 4 months. The first sign was diminution in appetite. There would follow progressive weakness, lethargy, and loss of weight. The animal would appear thin, listless, and weak. The eyes would be sunken and dull, as the emaciation became extreme. Often the animal was too weak to stand. There was never vomiting. Diarrhœa occurred only at infrequent intervals in a few instances, but all had loud rumblings and borborygmi in the abdomen. Unless the loops were resected these animals died.

On examination the blind intestinal segment was so greatly enlarged (Fig. 3) that it often appeared to occupy most of the abdomen. There was progressive dilatation so that the diameter of the blind end was often three to four times that of the normal intestine. The length of the segment was invariably shortened from that at the original operation. The walls were greatly hypertrophied so that the muscular portion was thrice that of the normal bowel. There was an amazing amount of material in these blind loops. The intestinal contents varied from thin, putrid material to a thick, cheesy substance. Interspersed in it were hair, bones, slivers of wood, glass, gravel, vegetable fiber, and seeds of many kinds. All this was churned together into a heterogeneous mass completely filling the lumen.

It is very instructive to watch these blind segments under the fluoroscope after they have been filled with barium. When the intestine is inactive, the loop appears uniformly filled and the walls are smooth. Peristalsis, beginning near the anastomosis, sweeps down to the blind end. As the strength of the waves increases, the incisura caused by them deepen until the lumen is nearly obliterated. The barium is carried up to the blind end which becomes dilated (Fig. 4). The dilatation increases as wave on wave drives the material into this cul-de-sac. After a variable period of time the peristaltic action becomes feeble and finally ceases. With this the barium flows back through the loop, the dilated blind end resumes its former size, and the remainder of the segment fills. There is no evidence of reversed peristalsis in this process. It is a flowing motion apparently initiated by the elasticity of the dilated blind end. Some of the barium spills over through the anastomosis into the distal intestine. It is probable that this is the mechanism of removal of the more fluid contents of the blind loop and the explanation of the retention of the solid foreign substance. The latter cannot flow out as does the fluid. At the end of a week, all the barium had been eliminated from the segment.

It has been noted that 6 of these dogs died after a period of anorexia, lethargy, and emaciation. It is presumed that death was due to the effect of the dilated blind loop. In order to prove this, however, it was thought necessary to demonstrate recovery from symptoms after excision of the loop. This was done in two instances. Since both were similar, the detailed recording of one will serve as an example:

Dog 32-249. A black and white long haired male of 50 pounds was operated upon December 9, 1932. A blind loop 4 feet long was made from a point 12 inches below the duodenojejunal junction. The continuity of the intestines was re-established by an isoperistaltic lateral anastomosis.

The animal had an uneventful convalescence with primary healing of the operative wound. He was perfectly well for over 3 months. In March of 1933 he began to lose his appetite. This progressed until in April he was taking less than half his daily ration. He became listless and lethargic. By the first of May, solid food was refused and only water or milk in small amounts was taken. Weight loss had become marked and lethargy was increased so that he moved only occasionally.

On May 24, it was noted: "the dog is thin, emaciated, so weak that he can barely stand, and lethargic. His eyes are dull and sunken. There are skin ulcerations over the sternum and hips, despite a soft bed. There has been neither vomiting nor diarrhœa. The blood non-protein nitrogen is 31 milligrams per 100 cubic centimeters, the chlorides 552 milligrams per 100 cubic centimeters, the sugar 92 milligrams per 100 cubic centimeters, and the

carbon dioxide 50 volumes per centum. He now weighs 25 pounds, just half his former weight."

He was given 500 cubic centimeters of 5 per cent glucose intravenously on May 25 and 26. On this day under ether anæsthesia the dilated blind loop was resected. After operation he was placed on a soft bed in a warm room. He made an uneventful recovery taking water and milk on the first 2 days after operation. He then took small amounts of solid food, table scraps mixed with salmon or liver. His appetite and intake increased, he gained weight and his energy returned. On August 17 he had regained his normal weight being 49 pounds 6 ounces. At this time he was occasionally taken out for a run. On these occasions he was energetic and active, skylarking about with exuberant spirits. If the walk was near good cover he would course back and forth looking for pheasants. He gave every indication of being a normal, healthy dog. Observation was continued for 6 weeks to make sure that recovery was complete.

This, and the other similar experiment (Dog 32-170) prove that the blind loop gave rise to a metabolic disturbance which is relieved by its excision.

Large jejunal blind loops. There were 11 experiments with long, blind, jejunal loops. Five were with loops 6 feet in length and 6 were 5 feet long. Of these, 2 animals lived for a longer period than the rest of the group. Dog 31-168 with a 6 foot loop lived 70 days and Dog 32-124 with a 5 foot loop lived 81 days. These animals presented the characteristic changes of intoxication described in the 6 animals with shorter segments. The blind loops were greatly dilated, thickened, and filled with inspissated material when examined at autopsy.

On the other hand, the 9 remaining dogs presented a sharply different picture. Soon after operation they had diarrhœa, loss of appetite, loss of weight, dehydration, and emaciation. They died in 5, 7, 10, 12, 14, 15, and 23 days after operation. At postmortem examination the loops were dilated with gas or fluid but were never markedly distended. It was thought that so much of the small intestine had been withdrawn from active use that these animals suffered from a lack of absorptive intestinal surface.

Blind loops in the terminal ileum. Five experiments were conducted upon blind loops of the terminal ileum. All were done with a 3 foot intestinal segment. Two animals died from peritonitis due to perforation of the blind loop by a foreign body. The 3 other animals lived. They showed no deviation from the normal, being well nourished, healthy, and active. They were sacrificed at the expiration of 8 months. Examination showed the blind loop to be greatly dilated, thickened, and filled with débris. The latter consisted of solid foreign material there being little or no intestinal contents present. The behavior of these animals may be contrasted with those which had jejunal loops of the same size. These latter were accompanied by a chronic intoxication.

Gastro-intestinal ulceration. At the postmortem examination not only the blind loop but also the stomach and intestines were opened and examined. In the last 22 examinations a special search was made for gastroduodenal ulceration (5). In the entire series of experiments, only one ulcer was found in the upper gastro-intestinal tract. This was in an animal which had had a 3 foot blind loop of the terminal ileum for 49 days and died of peritonitis.

It has been noted that 6 animals died from peritonitis following perforation of the loop. In all instances the wall was ulcerated through, but a foreign body was always in contact with the ulceration and usually protruded through the perforation. Other superficial ulcerations of the mucosa of these loops were occasionally noted but they, in turn, were in contact with a foreign body held by the débris in the lumen. These ulcerations of the blind loop were considered to be due to pressure necrosis of the foreign bodies in contact with the mucosa.

Blood chemistry changes. Determinations were usually made on the non-protein nitrogen, chlorides, carbon dioxide, and hæmoglobin. Occasionally sugar or blood volume determinations were added. In all, 261 estimations were made upon animals with blind loops. All readings were within normal limits. This being true, it is unnecessary to tabulate all the results. Those in one animal will serve as an example (Table I).

CLINICAL APPLICATION

About a year after this investigation was started, Estes and Holm reported 2 cases of

abdominal pain, borborygmi, diarrhœa, and debility following entero-anastomosis for intestinal obstruction. These patients had to have the blind segment of intestine resected before recovery occurred. One was a case of obstruction of the ileum following an appendiceal abscess in which an ileocolostomy was done. Thirty-two days later the blind intestine was found to have elongated from 3 to 7 feet in length and to have become dilated, inflamed, and ulcerated. In the other case, following a resection of the ileum for obstruction, a 4 inch blind end of intestine was left beyond an ileocolostomy to cover a raw surface. At the end of 69 days, the blind segment "had become greatly elongated and distended, and filled the lower half of the abdominal cavity." It was drained by an ileo-ileostomy. Nearly a year later it was found to be "fully 18 inches in length and 3 to 4 inches in diameter." The blind loop was resected. Holm subsequently reported his experimental findings separately. Pickhardt reports a case of right hemicolectomy with ileocolostomy where the blind pouch of ileum became elongated and dilated without causing symptoms. In the discussion of this case, DeWitt Stetten mentioned an instance of perforation of such a blind loop and Whipple told of a patient who developed typical pellagra associated with a chronic intestinal stasis.

These serve as examples of what may happen when a blind intestinal loop is left below an entero-anastomosis. That such trouble does not invariably occur is shown by the many patients who recover without incident after internal drainage of intestinal obstruction by a short-circuit above the constriction. For several years it has been the custom in this clinic to use entero-anastomosis instead of enterostomy for drainage of obstructed bowel. In only one instance was it necessary to do a secondary operation after this procedure. Here, the obstructed loop remained dilated so was resected.

H. M., No. 3335, male, aged 22 years, had had over a period of years, repeated attacks of colic associated with distention, visible peristalsis, and vomiting. He developed acute intestinal obstruction and was operated upon by Dr. J. J. Morton on February 22, 1929. The terminal ileum was bound down by a band which contained a pulsating artery.

TABLE I.—BLOOD CHEMISTRY DETERMINATIONS IN DOG 31-316, BLACK AND WHITE FOX TERRIER, MALE

Date	N. P. N.	Chlorides	CO_2 %	Hgb. %
9-28-1932	22	470	52	98
10-11-1932	28	483	46	90
10-16-1932	Operation—4 ft. blind jejunal loop			
10-18-1932	30	468	52	98
10-28-1932	34	410	58	100
11-1-1932	27	526	55	89
11-5-1932	30	483	50	89
11-11-1932	26	500	49	91
11-15-1932	Dog, though active, has begun to lose appetite			
11-18-1932	37	510	46	90
11-29-1932	27	555	50	90
12-5-1932	Moderate weight loss—still energetic			
12-9-1932	26	555	44	85
12-15-1932	26	525	44	91
12-25-1932	28	555	42	90
1-15-1933	Very thin, wasted and lethargic			
1-25-1933	28	525	44	86
1-26-1933	Died—Autopsy showed only a huge dilated blind loop filled with foreign débris and thick fluid.			

Rather than cut this, the dilated and collapsed loops were joined by a lateral anastomosis. Recovery was uneventful. Two months later a roentgenographic study showed stasis of barium in the ileal loop for 72 hours. Six months after operation there occurred abdominal discomfort, anorexia, nausea and vomiting on three occasions, and loss of weight. On August 31, 1929, a 2 foot blind segment which was thick walled, dilated, and ulcerated was resected, the previous anastomosis being left intact. There was diarrhœa for 3 weeks after which the patient was symptom free.

It may be argued that the reason patients do not more often develop symptoms of blind loop stasis after entero-anastomosis is that the obstruction is spontaneously relieved. Thus, adhesions may relax or resorb to allow the continuity of the tract to re-establish. But this is not invariably the explanation. In the following case the bowel was obstructed by recurrent carcinoma which obviously could not be expected to resorb.

H. R., No. 30304. The patient, an engineer, 48 years of age, was admitted to the hospital 6 months after the onset of symptoms of carcinoma of the rectum. The growth was fixed to the prostate and

seminal vesicles. The first stage of exploration and colostomy was done December 19, 1929. On January 4, 1930, a radical resection of the rectum, prostate, and seminal vesicles was done by Drs. Morton and W. W. Scott. He was discharged February 3, 1930, in good condition. On May 13, 1930, he returned with symptoms of acute intestinal obstruction. Exploration at this time showed the lower ileum to be constricted to the point of obstruction by a ring of recurrent carcinoma in the pelvis. An ileocolostomy was done with recovery. There were no symptoms indicative of blind loop obstruction prior to death 3½ months later.

The exact length of the blind loop in this case was not measured. It was long enough to reach from the obstruction in the pelvis to the lower ascending colon, probably between 12 and 18 inches in length. If one assumes that all long blind intestinal loops cause gastro-intestinal derangement, as the experiments would seem to show, then it is on a basis of the shortness of the loop in this case that one must explain the freedom from trouble. Certainly the carcinomatous obstruction would be permanent. It has been shown in dogs that short blind loops of one foot or under in length neither dilate nor cause symptoms. Those of greater size do dilate and if longer than 2 feet cause derangement of gastro-intestinal function. It is felt that on these two factors of permanence of the obstruction and length of the blind loop depend the eventual outcome.

The remarkable case reported by Little, Zerfas, and Trusler in which 8 years after entero-anastomosis and 4 years after the onset of nutritional disturbance pernicious anæmia developed, suggested the need of blood studies in the experimental animals. The level of hæmoglobin was found to be within normal limits in all instances. This may indicate that there is no effect or that the intestinal derangement was of too short a duration to produce the result. The problem of the relation of gastro-intestinal derangement to the development of anæmia is an interesting one. The production of a less severe but more prolonged chronic intestinal stasis may offer one means of attack on this problem.

The animals with long loops of 5 or 6 feet died soon after operation from dehydration and inanition. Their reaction and appearance were typical of animals suffering from lack of absorptive intestinal surface. Flint has studied this problem both experimentally and clinically. He concludes that the loss of from one-third to one-half of the small intestine is tolerated. To lose the use of more than this results in death. The length of small intestine varies within wide limits in the dog. Our measurements show a total length of from 8 to 14 feet, with an average of 11.2 feet. Owings, in using small dogs, found a variation of from 5 to 11 feet, with an average of 6.6 feet. Because of this variation in total intestinal length, a fixed length of blind loop will represent a variable percentage of the whole. Thus a 3 foot blind loop in a dog with a 5 foot small bowel and in one with a 14 foot intestine do not represent the same thing even though the size of the loop is identical. In the experiments now in progress the length of blind loop is being determined in terms of percentage of the whole length. This is felt to be a more accurate conception.

To me the intriguing part of this study is the effect of the medium sized blind loops. In those animals with 3 or 4 foot segments which developed nutritional disturbance, what caused the change? Obviously the derangement was due to the presence of the loop for its removal relieved the condition. But the behavior of the animals led one to feel that an intoxication had caused their gastro-intestinal derangement. There was no evidence of a mechanical disturbance as evidenced by vomiting or diarrhœa. The first effect was loss of appetite. The animal looked sick, refused to eat, became lethargic, and finally extremely emaciated. It is probable that the latter was due in part to starvation, for their food intake became extremely low. But the anorexia antedated the nutritional disturbance so that starvation alone will not explain the condition. Moreover the anorexia is preceded by several months of normal function. This suggests that the process of distention and accumulation of inspissated material must reach a critical level before deleterious effects are produced. But this is not invariably the case, for some greatly distended loops were observed that had caused no change in the animal's condition. In fact, it is amazing how

big some get and still remain asymptomatic. Consideration was given to the possible relation of ulceration of the mucosa being associated with the onset of intoxication. Ulceration does occur probably from necrosis by the pressure of foreign bodies. No exact correlation could be made, for the evidence on this point is insufficient. It is felt that further study of these animals with moderate sized blind loops is desirable. It is possible that by so doing more information may be obtained about the process of chronic intestinal stasis.

It is felt that the demonstration of the deleterious effects of blind intestinal loops in no way contra-indicates the use of entero-anastomosis in acute intestinal obstruction. This procedure is used only when it is inadvisable or impossible to remove the cause of the obstruction. The only alternative to its use is enterostomy. This procedure is often spoken of as a life saving operation. It is occasionally a life taking one for some patients die from an enterostomy. Aside from the dehydration, demineralization, and loss of normal secretion which follow from such externally draining fistulæ, there are other effects. The wound is messy, often excoriated and painful. When the need for the enterostomy is past, one occasionally has to resort to resection and anastomosis to close it. This adds to an already prolonged convalescence. Thus it is that we feel that entero-anastomosis with internal drainage of the obstructed bowel is preferable. To know that in rare instances the blind loop may dilate and cause symptoms is to be forewarned. This knowledge creates an obligation on one to follow these patients for a sufficiently long time to determine the end-result. If gastro-intestinal derangements occur then re-operation is indicated.

SUMMARY

1. When entero-anastomosis is used for internal drainage of intestinal obstruction, blind segments of intestine are left between the anastomosis and the point of obstruction. A study on 60 dogs was made to determine the fate of these blind loops. The results were as follows.

2. That portion of bowel below the obstruction where the peristaltic action is directed away from the blind end toward the anastomosis remains empty. It is a functionless segment of intestine.

3. In the segment above the obstruction where the peristaltic current is from the anastomosis toward the blind end, material is carried into and retained in the blind segment. These proximal blind loops may be subdivided according to their length.

a. Short loops of one foot or less apparently empty themselves and so do not become dilated.

b. If the blind segment is 2 feet long it becomes dilated and filled with inspissated material. Observations for over a year have revealed that unless perforation occurs, no symptoms are caused by these dilated loops.

c. Proximal blind loops from 3 to 4 feet long become filled with inspissated intestinal contents, foreign bodies, and débris to the end that enormous hypertrophy and dilatation follow. If perforation does not occur, these blind loops, after a free interval of 3 to 4 months, cause a chronic intoxication. This is characterized by anorexia, lassitude, and weakness which progress to marked lethargy, emaciation, and finally death. During this syndrome there is no evidence of mechanical gastro-intestinal disturbance as shown by the absence of vomiting or diarrhœa. The blood non-protein nitrogen, chlorides, carbon dioxide combining power, sugar, and hæmoglobin show no significant deviation from the normal. Resection of the blind loop allows complete recovery of the animal.

d. Blind loops of 5 to 6 feet long subtract such a large part of the total intestinal length that a majority of the animals die from inanition and dehydration. This effect was ascribed to a lack of adequate absorptive surface.

4. Cases having gastro-intestinal derangements from blind loops are cited and discussed. A case of this type from our clinic is presented.

5. It is felt that the rare occurrence of nutritional disturbances from blind loops following entero-anastomosis does not constitute a contra-indication to the operation. When release of the obstruction is inadvisable or impossible, internal drainage by entero-anastomosis is still considered preferable to external

drainage by an enterostomy. It is obligatory to follow all patients with an entero-anastomosis long enough to determine the end-result.

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THE EFFECTS OF CARBON DIOXIDE HYPERVENTILATION ON THE AERATION OF THE LUNGS IN PATIENTS AFTER OPERATION

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THE prevalence of postoperative pulmonary complications[1] is so well recognized it does not need emphasis here. In an attempt to find the cause of these complications numerous investigations have been made (5, 6, 10). Studies of postoperative pulmonary complications have been concerned chiefly with compilations of hospital records or investigations of the effects of laparotomy on the respiratory system. In earlier papers (1, 2) the writer recorded the results of more extensive measurements of these effects than had previously been made. It was shown that laparotomy produces certain profound changes in the respiration: (a) marked reduction in tidal air; (b) sharp increase in respiratory rate; (c) slight but not significant change in total ventilation; (d) rapid, shallow type of respiration which sets up a vicious cycle tending to increase further the respiratory rate; (e) great reduction in complemental air, greater following upper than lower abdominal operations in both men and women; (f) great reduction in supplemental air, greater following upper than lower abdominal operations in men but not in women; (g) about the same degree of crippling of the mechanism of forced inspiration and of forced expiration; (h) great reduction in vital capacity, the greater crippling in both sexes following upper abdominal operations, and greater crippling in men than in women; (i) marked decrease in subtidal lung volume and in maximum lung volume.

These pulmonary changes as enumerated, indicate severe injury of the respiratory function. The relation of this crippling to subsequent pathology has not been proved; however, several methods of therapy have been designed to counteract the imperfect ventilation of the lungs indicated by the above data. Notable is the stimulation of respiration by carbon dioxide proposed by Henderson (7), a method which has been both praised (8, 11, 12) and severely criticized (3, 9, 13).

This paper is an attempt to determine whether the treatment of patients after operation with carbon dioxide inhalation has any effect in preventing or even diminishing the crippling of the respiratory system which occurs following laparotomy.

Fifty cases were studied. Twenty-two patients received carbon dioxide treatment after laparotomy, and 28, used as controls,

[1] In September, 1933, Dr. John H. Powers of Cooperstown, New York, wrote to me asking if I knew of any data on postoperative vital capacity measurements in patients who had received carbon dioxide treatment as a prophylactic measure. Since I had such material, with controls, in my records, not only of vital capacity but also of tidal air, residual air, subtidal volume, and maximum lung volume, I have compiled it and herewith present it briefly.

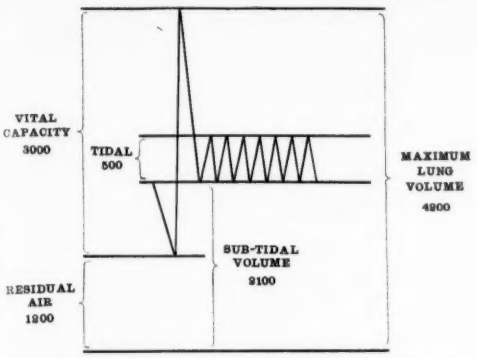

Fig. 1. A diagrammatic presentation of the factors concerned in this study. The numbers represent average volumes.

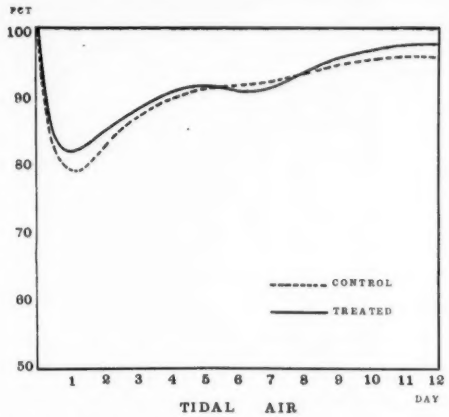

Fig. 2. Abscissa = days after operation.
Ordinate = postoperative percentage of preoperative values.

received no treatment. It is well known that pulmonary complications occur more frequently in men than in women. The ratio is usually expressed as 3 to 1; therefore it is important to have an equal distribution of sexes in the two series. Of the patients treated there are 8 men and 14 women; of the controls, 10 men and 18 women. The ratios are the same. As nearly as it is possible to do so, the same types of operations are considered in both groups. Of the treated patients, 11 underwent upper abdominal laparotomies, and 11 lower abdominal operations or herniorraphies, while in the control group 11 submitted to upper abdominal operations and 17 to lower. The cases investigated here are the same as those studied in relation to pulmonary complications by King (9). The postoperative carbon dioxide therapy has been described by him. Briefly, it consisted in a postoperative routine of treatment lasting for 3 or more days, starting after the patient had been returned to the ward. The carbon dioxide was administered by a full time graduate nurse. In all cases *each treatment produced marked hypernœa and was continued as*

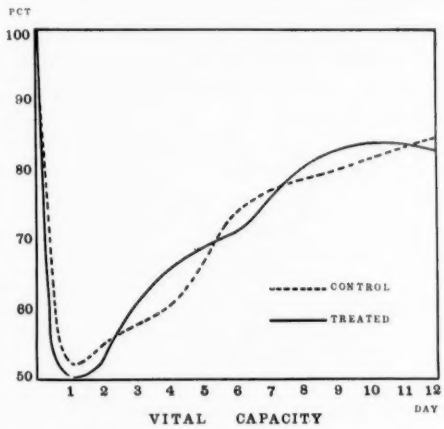

Fig. 3. Abscissa = days after operation.
Ordinate = postoperative percentage of preoperative values.

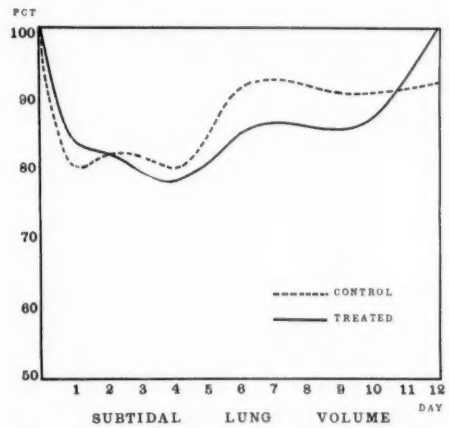

Fig. 4. Abscissa = days after operation.
Ordinate = postoperative percentage of preoperative values.

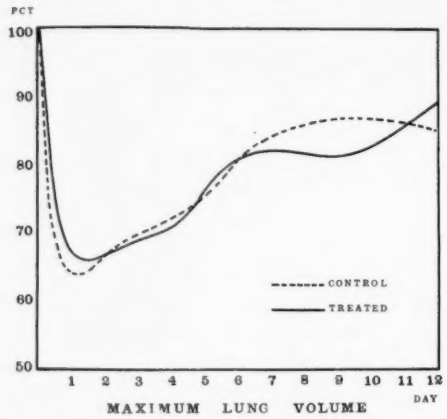

Fig. 5. Abscissa = days after operation.
Ordinate = postoperative percentage of pre-operative values.

long as the individual could endure it. Half the patients were treated by a method which consisted in having them rebreathe their own carbon dioxide through an 8-foot tube three times daily. Here, the limit of tolerance was 2 to 3 minutes for each treatment. The second half of the group was treated more intensively. These patients received carbon dioxide from a tank through a face funnel 5 to 8 times daily. When they were treated in this way, violent hypernœa was attained more slowly; they could endure the treatment from 5 to 10 minutes. The data on vital capacity (see below) were studied to determine if it were affected by degree of treatment. No significant difference was observed between the cases in which the patients were treated 3 times daily and in those receiving more treatment.

The data on which this study is based were obtained by using a Benedict Roth spirometer (1) with rubber mouth piece, nose clip, recording pen and drum. A modified (2) Benedict Roth spirometer was employed to make the lung volume measurements according to the method of Christie (4). Ten per cent was considered to be the limit of experimental error. The factors considered here are shown diagrammatically in Figure 1.

Tidal air (average-size breath). From an average of 20 equally spaced breaths over the 7 minute period.

TABLE I

	Days after operation
First period	1
Second period	2
Fourth period	3, 4
Sixth period	5, 6, 7
Ninth period	8, 9, 10
Twelfth period	11, 12, 13, 14

Vital capacity. Volume of a maximal expiration made following a maximal inspiration.

Subtidal volume. The volume of air remaining in the lungs at the end of a normal expiration (i.e., the volume of the lungs at rest).

Maximum lung volume. The volume of the lungs at the end of a maximal inspiration (vital capacity plus the volume of the absolute residual air).

The pulmonary volumes were corrected to 0 degrees C., and 760 millimeters mercury pressure. These data have been graphed. In order to simplify the curves, the data were combined in the following manner: all values obtained on the first day for a given curve were averaged; likewise, those obtained on the second; on the third and fourth days; all values on the fifth, sixth, and seventh days; on the eighth, ninth, and tenth days; and finally on the eleventh, twelfth, thirteenth, and fourteenth days. This is shown simply in Table I.

Since analyses of the respiration were made more frequently during the first 5 days after operation and less frequently thereafter, this grouping of periods gives more nearly equal weight to each point than if the average value were plotted each day. By this method each point on the curve represents an equal number of measurements. Every determination has been recalculated in terms of percentage of pre-operative value. The values determined before operation were arbitrarily rated 100 per cent. The graphs demonstrate percentage changes; the ordinates represent post-operative percentage of pre-operative values; the abscissæ represent the days after operation (Figs. 2, 3, 4, and 5).

In every case there is close relation of the "treated" and "control" curves. In no case has the divergence of the two curves exceeded the limit of experimental error.

SUMMARY AND CONCLUSION

It has previously been shown that laparotomy produces marked crippling of the respiratory system. Intermittent postoperative hyperventilation of the lungs caused by breathing a carbon dioxide rich air mixture has been employed as a means of reducing the damage. A "treated" group of patients was compared with a "control" group.

In the cases studied, carbon dioxide therapy following laparotomy had no effect in preventing the crippling of the respiratory system.

The writer wishes to acknowledge his great indebtedness to Dr. Donald King for the use of his records.

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ACUTE APPENDICITIS

A Study of the Correlation between the Time of Operation, the Pathology, and the Mortality

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IN reviewing ten recently published articles (1 to 10) on acute appendicitis, I find a total of 16,424 cases reported with 894 deaths, a mortality of 5.5 per cent. The lowest mortality was 3.5 per cent in a series of 600 cases and the highest 6.5 per cent in a series of 900 cases. Twenty years ago (11), I analyzed another series of ten articles comprising 4,343 cases with 279 deaths, or 6.2 per cent mortality.

Until the general mortality from this disease is very decidedly reduced from the death rates here shown, it must remain worth our while to review accumulated experiences from all possible viewpoints.

For the past 26 years, I have been analyzing and reanalyzing not only my own cases but those reported in the literature in an attempt to formulate some of the basic truths concerning the pathology and treatment of this disease. Without going into statistical details at this time I wish to emphasize two fundamental truths which I believe can be confirmed by any surgeon who will take the trouble to study his cases with reference thereto.

1. The operative mortality of acute appendicitis bears a definite relationship to the duration of the acute inflammatory process prior to the time of operation and, for practical purposes, the duration can be measured in terms of the day of the disease on which the patient is operated upon. The time of onset of the acute attack can almost always be accurately ascertained, for there is seldom any doubt in the patient's mind as to the very hour when the acute attack commenced.

In cases in which operation is done during the first 24 hours of the attack, the mortality in experienced hands, is almost negligible, about 1 per cent. In cases in which operation is done during the first half of the second day of the disease, the average mortality is from 2 to 3 per cent. After about 40 hours, the rate tends to rise sharply so that in cases in which operation is done on the third day of the attack, the operative mortality averages about 10 per cent. Generally speaking, fourth and fifth day operations are even more dangerous than third day operations. Beginning with the sixth day, the operative mortality starts to decline and by the ninth or tenth day, it again corresponds approximately with second day cases.[1]

The gross operative mortalities given for the third, fourth, and fifth day cases do not tell the whole truth concerning the mortality of operations performed at this period of the disease, because by this time the mild cases destined to have little or no peritoneal involvement are clinically sharply defined from the cases with peritonitis and the mortality is confined very largely to those cases in which clinical evidence of peritonitis is presented at the time of operation. Thus, the mortality in cases with peritonitis in which operation is done at this period of the attack is much higher than shown by the combined figures.

The facts mentioned concerning the relation of the time element to the mortality of acute appendicitis have been recognized for many years but they will bear reiterating because today, just as 30 or 40 years ago, the

[1]In order to check again the general accuracy of the statements contained in this paragraph relative to the mortality rates in relation to the time element, I have summarized some recently reported data with the following results.

	Cases	Deaths	Death rate per cent
Operated upon first day of attack	1507	20	1.3
Operated upon second day of attack	912	33	3.6
Operated upon third day of attack	663	56	8.9
Operated upon fourth day of attack	356	46	12.9
Operated upon fifth day of attack	442	49	11.6
Operated upon sixth day of attack	346	29	8.4
Operated upon 7th, 8th, and 9th days of attack	178	5	2.8
Operated upon 10th day of attack and later	288	7	2.4

problem of reducing the mortality centers very largely around those patients seen too late for an early safe operation and too early for a safe late operation. Of course the ideal solution would be to have all patients come to operation during the first 24 or 36 hours of the attack,[1] but experience has apparently demonstrated that as long as human nature and human judgment remain what they are, surgeons will continue to be called upon to treat a considerable number of late cases of appendicitis.

The second basic point which I wish to emphasize is the fact that the mortality rate as observed from day to day in this disease is inseparably associated with a corresponding sequence of changes in the inflammatory process itself. It is perfectly true that some appendices suffer vastly more initial damage than do others. Also, it is true that the extent of peritoneal involvement at any given period varies widely in different cases. Nevertheless, acute appendicitis is an acute inflammatory process and this process progresses from day to day through a definite and orderly series of changes in both the appendix and the complicating peritoneal lesion. While it is technically possible to remove the appendix during all stages of the disease, experience has very definitely shown that the amenability of the peritoneal lesion to operative methods of treatment varies as the character of the lesion changes. In much of the literature, the fluid exudates found on the first day are classed as diffuse peritonitis. Likewise, the localized fluid collections are described as localized abscesses. This has led to a good deal of statistical confusion when these early lesions accompanied by an almost negligible operative mortality have been classified along with third and fourth day lesions of somewhat similar extent of peritoneal involvement, the fact being ignored that the older peritoneal lesions are associated with an operative mortality many times that of the earlier lesions. Actually, there is very little resemblance histologically between the peritoneal lesions encountered during the first day of the attack and the peritoneal lesions of the third and subsequent days. According to my observations, the increased operative mortality of the later periods is as closely related to the character of the lesion as it is to the extent of the lesion.

About 30 per cent of the patients operated upon during the first day of the disease present noteworthy peritoneal exudates, but, be the exudate fibrinous or fluid, and regardless of its extent, the peritoneal surfaces are not yet seriously damaged and, if further contamination from the grossly infected appendix is prevented by removal of the appendix, experience has shown that the peritoneal surfaces are, in the vast majority of cases, amply able to take care of any infection present. It is probably worse than useless to attempt drainage in these early cases; first, because it is unnecessary and, second, because the foreign body acts as a handicap rather than an aid to the natural processes of repair.

During the second day of the disease approximately 40 per cent of patients operated upon present noteworthy peritoneal lesions. The percentage of cases presenting peritoneal lesions has increased, and the histological characteristics, especially at some distance from the appendix, may vary considerably because not all peritoneal areas are involved at the same time—but, generally speaking, the peritoneal lesion in the immediate neighborhood of the appendix has reached the stage of capillary engorgement and marked leucocytic infiltration with beginning roughening of the peritoneal surfaces. Notwithstanding the much more formidable pathology encountered in patients operated upon on the second day of the disease, experience has shown that in the great majority of cases the peritoneum is still able to take care of whatever infection there may be after the appendix is removed.

Both clinical and experimental evidences seem to show very conclusively that the second day peritoneal lesions are essentially undrainable. Certainly experience has shown that the great majority of these patients do just as well or probably better without drain-

[1] Four series of cases studied by the writer show the percentage coming to operation during first 48 hours.

	Per cent
1899 to 1905	10
1907 to 1914	42
1914 to 1923	65
1923 to 1933	80

age. Twenty years ago, I attempted to use drainage in most of these cases but during the past 10 years in cases in which operation is done during the first and second days of the disease, except for a few patients operated upon after 40 hours, I have used drainage only in those cases in which I have had to open retroperitoneal spaces to dissect out gangrenous or grossly perforated appendices. I have never encountered any trouble attributable to letting the peritoneum fight its own fight at this stage uncomplicated by foreign bodies such as drains.

The proportion of patients operated upon on the third day of the disease who present noteworthy evidences of peritoneal involvement varies considerably in the experience of the individual operator. In general, it may be said that from 60 to 80 per cent of the cases referred to the surgeon at this period present definite evidences of peritoneal involvement, but this high percentage represents in part a selection of cases because by the third day many patients destined to run a mild course have already demonstrated to the satisfaction of the family physician that they will probably recover from their present attack without the necessity of calling a surgeon. By the third day, the operative mortality which began to climb in the cases in which operation was done during the latter half of the second day jumps suddenly to approximately 10 per cent for all cases in which operation is done during the third day. This increased mortality is confined not alone to cases in which the patient presents generalized free fluid in the peritoneal cavity but also to cases which present only local peritonitis and so called localized abscesses.

This latter point should be especially emphasized because the terrific mortality encountered from the third day on in cases in which operation is done for so called diffuse peritonitis has served to blind surgeons to the fact that in the aggregate a not inconsiderable number of the deaths following operations performed on the third, fourth, and fifth days of the attack really occur in cases in which the patients presented rather localized lesions at the time of operation.

The sudden increase in the operative mortality noted in the third day of the disease is coincident with a fundamental change in the histology of the peritoneal lesion. The intraperitoneal exudate is now of a distinctly purulent character. The gross changes in the involved peritoneum, especially in the immediate neighborhood of the appendix, are very noticeable, due in part to the more abundant fibrin, and in part to the changes in the peritoneum incident to the beginning organization, which seems in all cases first to become noticeable on the third day following the involvement of any given area of peritoneum. Limiting adhesions are now fairly well developed in most instances, but the lesions are, as yet, of a decidedly diffuse character, the area involved being much more extensive than at a later period; and there is as yet little or no evidence of the formation of sharply defined abscess cavities. It is at this time that pus is encountered extending irregularly between the various structures lying within the area of peritoneum involved.

The outstanding characteristic which distinguishes the third day peritoneal lesion is the presence of fibroblasts in the histological picture. Each square centimeter of involved peritoneum no longer has the histological characteristics and functional capacities of peritoneum because the involved surfaces have now taken on the characteristics of granulation tissue. This means that each unit area of peritoneal involvement has now begun to take on the histological characteristics of a true abscess cavity. Experience corroborates this concept because it is no longer possible to close these late cases without drainage. To accomplish operative cure, purulent collections encountered at this period must be drained but the anatomical conditions encountered are usually such as to make efficient drainage difficult or impossible. In short, the third day appendix case is very apt to present a highly infected peritoneal lesion in a patient who has not yet developed any considerable immunity to the infection, and while the peritoneal lesion is such that efficient drainage is essential for success, the lesion encountered is of a diffuse multiloculated type which is technically almost impossible to drain.

The mortality in patients operated upon during the fourth and fifth days is in general

even higher than in third day cases and in many series has reached as high as 15 or more per cent. We are still dealing with a highly infected, essentially non-drainable peritoneal lesion. By the fourth or fifth days the process of organization is well established, the previously existing fibrinous adhesions are being replaced by organizing granulation tissue, which is also noticeable over the surfaces of the peritoneum in direct contact with purulent fluid exudates. This granulation tissue serves to encapsulate the pus, and it is from this time on that the formation of definitely defined abscess cavities is observed, they being at first usually more or less multilocular, but later becoming more localized to form, usually, one well defined cavity.

The decrease in operative mortality which begins about the sixth day and proceeds rapidly thereafter is coincident with, and undoubtedly bears a definite relationship to, readily observable clinical and pathological phenomena. It is not necessary to go into detail relative to the well known clinical phenomena such as the subsidence of the pulse rate and the drop in temperature which in severe cases usually reaches normal for the first time on the morning of the ninth day. Undoubtedly, these phenomena signify the development of a relative immunity against the infection. This relative immunity is clinically demonstrable by the fact that from now on the sutured portions of appendectomy wounds seldom break down from infection whereas a large proportion of wounds made during the high temperature period of the attack do break down from infection.

The clinical features mentioned here have been emphasized by many writers but much of the recent literature has failed to emphasize the fact that purulent collections encountered after about the seventh day are contained in sharply defined abscess cavities readily drainable and in no way comparable to the ill defined, essentially undrainable intraperitoneal collections of fluid and pus encountered in the early and intermediate stages of the disease.

The number of patients presenting pus outside of the appendix shows practically no increase after the third day, and, except when there is a clinical history of a later acute exacerbation of peritoneal symptoms, there is no evidence of an increase in the area of peritoneal involvement after this time. On the contrary, after the process of organization is well established, on the fourth or fifth days, there is every evidence of a progressive diminution in the extent of the peritoneal involvement, which becomes sharply localized and limited by the organizing adhesions.

This phase of the repair process, which results in the more or less complete resolution of the peritoneal lesion beyond the immediate wall of an abscess, if present, is well shown in cases coming to operation on the tenth and eleventh days, the clinical picture having been on admission that of a severe diffuse peritonitis. In these cases, the abscess cavities are often surrounded by a narrow zone of organizing adhesions, while the peritoneum of the ascending colon and nearby loops of small intestine beyond the wall of the abscess cavity, although non-adherent, is thickened, reddish, and distinctly granular, without fibrin or other evidences of an acute lesion.

From July, 1907, to January 1, 1934, my associate, Dr. C. W. Woodall, and I have operated upon 1,004 cases of acute appendicitis. Tables I, II, and III summarize the results obtained in the three periods, 1907 to 1914, 1915 to 1923, and 1924 to 1933.

Although pathological and clinical studies undertaken previous to 1907 had convinced me of the general advisability of deferred operations during the high mortality period of the disease, when I began operating upon patients referred to me by other physicians, I soon found that while it was technically easy and safe to carry out the Ochsner treatment on intermediate period cases with peritonitis, it was nevertheless morally very difficult not to operate upon most patients as soon as referred. This difficulty arose from the fact that when operation is postponed by the surgeon because a patient has not been referred until the case is 3 or 4 days old, the family physician may be at least in part responsible for some of the delay.

Between 1907 and 1914 (see Table I), I treated 116 cases of acute appendicitis with 6.9 per cent mortality. In approximately 58 per cent of these cases the patients had been

TABLE I.—ANALYSIS OF 116 CASES OF ACUTE APPENDICITIS TREATED 1907–1914

	Treated	Per cent of total	Died
Acute diffuse or gangrenous—operated on during first 48 hours of attack	49	42.2	0
Acute—with slight or no peritoneal symptoms—operated on after 48 hours	18	15.5	0
Acute—with well marked peritonitis operated on third to fifth day of attack	8	6.9	4
Patients seen after 40 hours with well marked peritonitis. Ochsner treatment—operated on later	22	19.0	2
Mild cases. Ochsner treatment only	2	1.7	0
Late cases with localized abscess at time of admission to hospital	16	13.8	1
Rupture of old undiagnosed appendicular abscess into general peritoneal cavity. Moribund on admission	1	.9	1
	116	100.00	(6.9%) 8

TABLE II.—ANALYSIS OF 380 CASES OF ACUTE APPENDICITIS TREATED 1915–1923

	Treated	Per cent of total	Died
Acute diffuse or gangrenous—operated on during first 24 hours of attack	118	31.0	1
Acute diffuse or gangrenous—operated on during second 24 hours of attack	128	33.6	4
Acute, with slight or no peritoneal symptoms—operated on after 48 hrs.	46	12.2	0
Acute, with well marked peritonitis—operated on third to sixth day of attack	15	3.9	6
Patients seen after 48 hours with well marked peritonitis—Ochsner treatment	28	7.4	4
Mild cases, patients seen late and treated by Ochsner and later operated on	4	1.2	0
Late cases with localized abscesses at time of admission to hospital	35	9.2	4
Rupture of old undiagnosed appendicular abscess into general peritoneal cavity	6	1.5	3
	380	100.00	(5.5%) 21

referred to me 48 or more hours after the attack. Drastic cathartics, the immediate cause of most really dangerous complications in appendicitis, had been administered in a considerable number of cases. My results compared not unfavorably with currently reported series. Nevertheless, it was perfectly evident that one-half of my total mortality had occurred in a group of 8 cases in which I had tried to extend the time limit for operation in severe cases into the third day of the attack or later. With possibly one exception, none of the 8 patients immediately operated upon had appeared to be as ill as those included in the group of 22 cases with marked peritonitis in which treatment by the Ochsner method was used with only 2 deaths. As I studied these cases at the time, it seemed perfectly obvious that at least 2 or 3 of the 8 deaths could have been avoided had I refused absolutely to operate during the intermediate stage of the disease.

Between 1915 and 1923, I treated 380 cases of acute appendicitis with 21 deaths, or 5.6 per cent mortality. Table II summarizes this series. One hundred and eighteen patients were operated on during the first day of the attack, with 1 death. One hundred and twenty-eight were operated upon during the second day of the disease, with 3 deaths.

Ninety-three cases were referred for treatment between the third and sixth days of the attack. Fifty of these 93 cases appeared clinically to be mild cases with little evidence of peritonitis. Forty-six were operated upon immediately and 4 were treated conservatively until temperature had subsided, when operation was done. There were no deaths in this group of 50 late but mild cases.

Forty-three of the late referred cases had definite evidences of more or less extensive peritonitis. Of these, 28 were placed on the Ochsner treatment and later operated upon, with 4 deaths; 15 were operated upon immediately, with 6 deaths.

Were the two groups exactly comparable, the difference between 4 deaths in 28 cases and 6 deaths in 15 cases would be suggestive but statistically of little significance. But as a matter of fact, the two groups are not comparable, because the clinically severe diffuse peritonitis patients were all treated by the Ochsner method whereas the 15 patients with peritoneal symptoms operated upon immediately were all of them at the time of operation thought to have relatively limited peritoneal involvement and therefore to be comparatively safe risks for immediate operation. A review of the individual histories left no doubt in my mind that at least 3 or 4 of these 6 deaths could have been avoided had operation been deferred in these cases.

There were 4 deaths among the 35 cases referred with localized abscess 7 or more days after onset of the attack. This is an unusually high death rate for this class of case but analysis of individual cases shows that 3 of the deaths were due to unavoidable accidents and complications.

In the period 1924 to 1933, we have treated 508 cases of acute appendicitis with 11 deaths, or a mortality rate of only 2.16 per cent. This is less than one-third the mortality of the 1907–1914 series and considerably less than one-half the death rate of the 1915–1923 series. A glance at Tables I, II, and III will show that this reduction is due to two chief factors: First, a larger number of cases operated upon early, 42.2 per cent in the first series, 64.6 per cent in the second series, and 79.6 per cent in the third series; and, second, a reduction by more than half in the mortality in cases seen during the late high mortality period of the disease. As a matter of fact, from a purely statistical viewpoint, the reduction from the 5.8 per cent combined mortality of the first 495 cases to the 2.16 per cent mortality of the last 508 cases is approximately half attributable to a larger proportion of cases seen early and the other half attributable to the 60 per cent reduction in the mortality of cases first seen during the high mortality period of the disease.

Combining Tables I, II, and III, we find that in the entire series of 1,004 acute cases 20 deaths, or one-half of the total, occurred in the 113 cases admitted with well marked evidences of peritonitis during the high mortality period of the disease. Of these 113 cases, 31 were operated upon immediately with 13 deaths, a mortality of 42 per cent. Eighty-two were treated conservatively until the acute symptoms had subsided and later were operated upon with 7 deaths, or a mortality of only 8.5 per cent.

Clinically, the two groups were not strictly comparable at the time of admission because the cases operated upon immediately were none of them considered to be particularly bad operative risks at the time, while the more desperately ill cases were not operated upon and therefore, are included in the group of 82 cases with deferred operations. Had the 31 immediately operated upon cases been treated as were the 82 with deferred operations, I feel reasonably certain that the mortality rate in this group would have been at least as low as was the mortality in the group treated by the Ochsner method. Had this been the case, it would have meant 10 deaths less and resulted in a 25 per cent reduction in the total mortality for the series.

TABLE III.—ANALYSIS OF 508 CASES OF ACUTE APPENDICITIS TREATED 1924–1933

	Treated	Per cent of total	Died
Acute diffuse or gangrenous—operated on during first 24 hours of attack	279	55.0	3
Acute diffuse or gangrenous—operated on during second 24 hours of attack	125	24.6	2
Acute, with slight or no peritoneal symptoms—operated on after 48 hrs.	24	4.7	0
Acute cases with well marked peritonitis, patients operated on third to sixth day of attack	8	1.6	3
Cases seen after 48 hours with well marked peritonitis—Ochsner treatment	32	6.3	1
Mild cases seen third day or later and operation deferred—operated on as interval cases	18	3.5	0
Late cases with localized abscesses at time of admission to hospital	20	3.9	1
Rupture of old undiagnosed appendicular abscess into general peritoneal cavity	2	.4	1
	508	100.00	(2.16%)11

In conclusion, let me state that while the factual data reported in this paper are based on a series of only 1,004 cases studied in detail by me personally, I have analyzed and combined the data presented in a large number of articles on acute appendicitis appearing in the domestic and foreign literature during the past 30 years and nowhere have I been able to find any definite factual data which seem to lead to conclusions definitely opposed to those I have expressed. On the contrary, most of the data which have been presented in such form as to allow re-analyzing along the lines here set forth, do, I believe, tend to confirm the conclusions emphasized in this paper.

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THE LIPID COMPOSITION OF WHITE BLOOD CELLS IN WOMEN DURING PREGNANCY, LACTATION, AND THE PUERPERIUM

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THE lipid composition of white blood cells in normal, non-menstruating, non-pregnant women has been reported in a previous communication (5) in which it was shown that the leucocytes lay midway between blood plasma and the active body tissues in respect to their fat content. The outstanding characteristic in the fat analysis of these cells was shown to be the relatively high percentage of phospholipid, a finding which corroborated earlier findings of large amounts of phospholipid in the blood leucocytes of dogs (3). In addition, however, neutral fat and free cholesterol were present in amounts greater than those commonly found in blood plasma while cholesterol ester constituted a lower percentage of the total cholesterol than in plasma but higher than in most body tissues. There was also noted a wide variation in the lipid values which suggested that the leucocytes might well be found to exhibit an altered fatty composition in response to altered demands of body metabolism. During the course of an investigation into the nature of pregnancy lipæmia (6), an opportunity was afforded to study simultaneously the fat content of the white blood corpuscles at the termination of pregnancy and during the puerperium and the results are reported below.

A review of the literature revealed that there exists a very meager knowledge concerning the metabolism of the white blood cells. Their basal metabolism has been investigated by Fusita who found, using the Warburg technique, that the basal metabolism of these cells was analogous to that of embryonic cells but distinct from carcinomatous cells. Regarding their carbohydrate metabolism, Stockinger and Freese noted that as sugar disappeared from the blood and lactic acid accumulated during fevers, there were fewer granulations in the white cells which suggested to them that these histological particles may be organs for sugar storage. Fleischmann (15) was able to demonstrate that the respiration and permeability of horse leucocytes are affected by mineral salts, particularly the alkali cations and halide anions.

A number of enzymes have also been found present in the white blood cells. Stern's results suggest the presence of a catalase which is similar in nature to this ferment in the liver and red blood cells. In horse leucocytes, Willstaetter and Rohdewald have shown there occur amylase, maltase, and trypsin. In 1910, Fiessinger and Marie presented a treatise on the facts then known concerning the proteolytic and lipolytic ferments of the leucocytes. Resch in 1915 postulated that the lipase was derived chiefly from the lymphocytes but Nees, by plating pus on fatty media, later found that fat was split by polymorphonuclear cells as well as lymphocytes. While these results are open to the criticism of bacterial contamination, Fleischmann (14) has recently demonstrated by the improved Rona-Lasnitzki manometric technique the presence of lipase in the leucocytes obtained from sterile peritoneal fluid of rabbits.

Concerning the metabolism of fats attacked by this lipolytic ferment, little is known. Histological methods, lipoid and fat stains being used, constituted the earliest means of investigation and have, indeed, been used

well into the present decade. Ciaccio in 1909 noted lipoid inclusions microscopically in the large mononuclears, amphophile, neutrophile, and eosinophile cells, these masses being relatively larger in size during infection and intoxication. With cresol blue as a selective stain, Hammar in 1913 perceived the presence of lipoid granules in the leucocytes, the particles becoming more evident during autolysis of the cells. Savini in 1921 described the presence of lipoid granules by means of Sharlach R and similar stains in granular and non-granular leucocytes. Sehrt (31) in 1927 noted a relation between oxidase activity and the white cell lipoids and prepared a monograph (32) on the subject while Goldmann demonstrated in 1929 that the granules which stain with Sudan III are morphologically identical with those which exhibit the oxidase and peroxidase reactions. There appears, therefore, to be a close relationship between the lipoids of the white blood cells and their rate of oxidation and respiration.

Methods of a more strictly chemical nature have, however, been used to investigate the lipid composition of the leucocytes simultaneously with the histological procedures as noted above. In 1910 Mancini obtained suggestive evidence relative to the lipid composition of the white blood cells by combustion analysis of the horse leucocytes before and after washing with alcohol, ether, or chloroform. He found a decrease in the percentage of phosphorus and sulphur following extraction with the fat solvents and postulated, on this evidence, the presence of "sulphatides" and phosphatides in the white blood corpuscles. In 1913 Wacker and Hueck applied a direct lipid analysis to horse leucocytes and demonstrated that the dried cells contained 1,729 milligrams per cent free cholesterol and 40 milligrams per cent ester cholesterol. In 1931 Cheng investigated the fatty acids of the gelatinous bone marrow, which contains large numbers of white blood cells and is the seat of origin for many of them, and found the presence of oleic and highly unsaturated fatty acids such as arachidonic acid. Evidence of a similar nature was obtained by Epstein and Lorenz studying the fat chemistry of Niemann-Pick disease: in this condition the liver, spleen, and reticulo-endothelial system generally are engorged with leucocytes, and analysis of these organs revealed a marked increase in lecithin and free cholesterol. These data suggested that white blood cells contained large amounts of phospholipid and free cholesterol and smaller amounts of cholesterol ester. In the previous communications (3, 5) the author was able to verify this by direct lipid micro-analysis, demonstrating the quantitative relationships of these lipids and the further presence in considerable quantity of neutral fat.

The connection between fat metabolism and the white blood cells has also been demonstrated in a different manner by studying the effect of injesting lipids on the white cell count and differential count. Twenty years ago, Hamburger and de Haan found that while free fatty acids decreased the phagocytic activity of leucocytes, soaps augmented this important function of the cells. In 1924 Okuneff showed that the lipoids and waxy substances of the tubercle bacillus produced a polymorphonuclear leucocytosis and a decrease or but slight increase in the lymphocyte count. Brandberg demonstrated that the ethyl esters of the fatty acids present in chaulmoogra oil, which contains the interesting group of cyclic fatty acids notably hydnocarpic acid ($C_{18}H_{28}O_2$) and chaulmoogric acid ($C_{18}H_{32}O_2$) caused a pronounced lymphocytosis and a polymorphonuclear leucopenia. And, finally, Hirsch has shown that lecithin intravenously causes a polymorphonuclear leucocytosis. In spite of the inconclusive nature of much of this work, there appears a general element of similarity in the results. From these the generalization may be made that esters or soaps of fatty acids and lecithin which, in a sense, may be regarded as an ester of the fatty acids, excite a lymphocytosis while cholesterol and the higher alcohols or waxes a polymorphonuclear leucocytosis.

Wherever there occurs a physiological or pathological variation in the metabolism of the white blood cells, one may expect to find an altered fat content. It is the purpose of this series of investigations to record the nature and the extent of such changes in order to throw further light onto the metabolism of these important cells in pregnancy, fever,

TABLE I.—THE LIPID COMPOSITION OF THE WHITE BLOOD CELLS IN PREGNANCY AT TERM, DURING LACTATION AND THE PUERPERIUM

The results are expressed in milligrams per 100 grams of cells.

Case No.	Age	Parity	Days postpartum	Total lipid	Composition of total lipid					
					Total fatty acid	Neutral fat	Phospholipid	Cholesterol		
								Total	Ester	Free
1	30	0	0*	603	344	177	257	165	6	159
			3	2,174	1,265	280	1,402	426	99	327
			6	2,394	1,397	304	1,560	462	102	360
			21	1,006	612	258	497	216	50	166
2	22	0	0	744	435	128	442	155	29	126
			2	894	551	236	490	168	0	170
			6	2,015	1,328	653	1,058	304	0	314
3	17	0	0	905	619	408	346	151	0	151
			1	1,077	807	488	496	81	18	63
			3	800	410	76	507	217	0	224
			10	1,167	677	249	644	263	16	247
4	31	3	0	882	521	174	522	178	12	166
5	37	3	0	925	576	242	493	173	25	148
			3	2,351	1,570	702	1,340	299	15	284
			7	2,566	1,720	762	1,460	316	42	358
6	21	0	0	1,030	597	169	526	249	128	121
			2	1,431	919	380	755	242	81	161
			9	1,969	1,237	422	1,170	322	82	240
7	32	7	0	1,343	855	467	600	264	18	246
8	24	0	0	1,456	880	20	1,250	158	41	117
			1	1,427	925	407	785	220	22	198
			14	2,046	1,363	718	1,020	308	0	315
9	27	0	0	1,822	968	0	1,436	375	16	359
10	23	0	0	2,067	977	34	1,200	688	216	472
			2	2,117	1,396	663	1,050	337	100	237
			7	3,149	2,057	782	1,860	432	112	320
11	43	11	0	2,713	1,797	878	1,260	452	183	269
			1	2,200	1,450	703	1,100	347	75	272
			3	1,131	695	251	548	241	136	105
			7	1,368	785	202	640	360	248	112
			12	1,892	1,000	157	972	562	300	262

*The "0" days postpartum indicates the prepartum specimen as described in the text.

menstruation, digestion, etc. The present contribution is concerned with such observations during the termination of pregnancy and the puerperium in women.

From the early months of pregnancy there occurs an increase in the number of white blood cells, the "physiologic leucocytosis of pregnancy" of Virchow, which may reach 15,000 (10) or 20,000 (1). The increase occurs not only in the polymorphonuclear leucocytes but also in the immature myelocytes indicating the rapid production of new leucocytes by the bone marrow. The increase is more marked in primiparæ and is considered by Dietrich due to the intoxication resulting from pregnancy. During labor and the first day postpartum there is a further marked leucocytosis, the white cell count then falling gradually to normal intercepted only by a slight rise three to four days postpartum which coincides with the onset of lactation. The fat metabolism of white blood cells has been investigated, as reported below, during these states by analysis of the lipid content (a) at the termination of pregnancy, (b) during the first day or two postpartum, (c) during lactation, and (d) in the later puerperium.

METHODS

The general principles in the selection and care of patients utilized for experimental study conformed to the standard laid down in a former paper on the study of non-pregnant women (4). The subjects were chosen from the prenatal clinics of the Strong Memorial Hospital, referred in to the obstetrical divisions a few days before the expected date of confinement where they were thoroughly examined to exclude conditions other than pregnancy which are known to affect the level of blood lipids, and then placed on a standard balanced diet and kept in bed for about a week before an analysis was made of their white blood cells. A sample of blood was taken before delivery and after parturition at various times as indicated in Table I.

Blood was drawn from the arm veins in the morning following a 15 to 16 hour fast, citrated and immediately centrifuged. In many cases it was possible then to remove the white cell layer with a pair of clean forceps, after the plasma was drawn off, but in other cases the leucocytes were non-adherent and a different procedure was adopted. The white cells, with the immediately adjacent layers of red cells and

plasma were transferred with a pipette to a small centrifuge tube and again centrifuged. It was then possible to draw off the wider layer of semi-fluid leucocytes with a small pipette. Fifty cubic centimeters of blood gave sufficient white cells for a complete lipid analysis.

Following separation of the leucocytes, they were quickly weighed (wet weight), ground up with cleaned sand, and extracted with alcohol-ether after the manner previously reported (Boyd, 5). The extracts, made up to a volume of 100 cubic centimeters, were analyzed for their total fatty acid, phospholipid, total cholesterol, and free cholesterol by the oxidative micro-analysis procedure described in detail in a former paper (4). The remaining lipid values, total lipid, neutral fat, ester cholesterol, and the various component fatty acids, were arrived at by calculation (4).

Since writing the original paper on methods (4), two papers have appeared by other authors (23, 26) in which the oxidative, digitonin micro-method for cholesterol has been criticized and alternative methods proposed. The gravimetric modification as proposed by Man and Peters appears to offer no advantage as in one case impurities are weighed while in the other they are oxidized. Oberman and Milton (26) also cite this objection, viz., that extraneous matter in the digitonin precipitate may be included in the final oxidation and in addition state the oxidative procedure itself is uncertain. The first of these objections to the original method has been overcome by introducing a careful washing of the digitonin precipitate with water, acetone, and ether whereas the second objection has also been removed by determining and using the procedure necessary for 100 per cent oxidation of the cholesterol digitonide which is considerably more resistant to oxidation than phospholipid or fatty acid (4). In the experience of the author, the most vulnerable step in the whole method for total cholesterol, as herein used, is the saponification procedure. Unless the directions as previously reported (4) are strictly followed, and if the hydrolyzing mixture is concentrated below a volume of 2 cubic centimeters, cholesterol becomes so altered that it is rendered only partially precipitable with digitonin. Oberman and Milton (26) noted these dangers during saponification and state that in the presence of acid digitonin precipitation is incomplete. Hence they do not acidify their mixture after saponification but extract directly from the alkaline medium with petroleum ether.

EXPERIMENTAL RESULTS

From an analysis of the lipid content in the white blood cells of 11 cases of pregnancy at term (Table I) no general trends from the non-pregnant levels, as previously reported (5), could be deduced. On the average, the fat content of the leucocytes was reduced in pregnancy by one quarter, the decrease being most marked in neutral fat and cholesterol ester, each of which was lowered 50 per cent, on the average, from the non-pregnant levels. Free cholesterol and phospholipid showed little variation. It is doubtful, however, if a comparison of mean values in this connection has much significance. Practically all the values noted in pregnancy fell within or very close to the range of levels for the non-pregnant woman as formerly deduced statistically (5), and it was only by considering mean values that any variation was obvious, as noted above. A number of cases showed high phospholipid and free cholesterol with low neutral fat and cholesterol ester values, which combination, according to Bloor, Okey, and Corner indicates active tissue. On the other hand, the converse combination also occurred and furthermore such groupings of the lipids were encountered in normal non-pregnant women (5). Hence it is not possible to draw any causal relationship between pregnancy and the lipid composition of the white cells from this series of analyses. This much is true, however, that there is a wide variation in the lipid composition of the white blood cells in pregnancy, and if the postulate of Bloor, Okey, and Corner that activity of the sow corpus luteum is associated with definite changes in lipid composition, may be generalized to include all tissues, then one may state there is a wide variation in the activity of the blood leucocytes in pregnancy. The relation of activity as so determined to the incidence of temperatures and puerperal infection is a problem of utmost importance to the obstetrician and is at present being further investigated.

Following parturition was noted a more definite trend in the leucocyte lipid content and distribution which exhibited, in the cases studied, a fair degree of uniformity. The total lipid content was increased, more markedly in patients with low values before delivery. In cases examined during the first 24 hours postpartum, little change in the total lipid content was found, and occasionally an actual decrease was present, although this period exhibits a marked leucocytosis, as noted above. Between the third to seventh day postpartum the fat of the leucocytes rose, and in most cases the rise was marked, so that by the first part of the second week after delivery, the leucocytes contained 2 to 3 per cent total lipid. This period corresponds clinically to the establishment of an abundant flow of milk, marked involution of the uterus, a change from red to creamy yellow lochia, and a marked improvement in the general bearing of the patient. Patients examined in the second week of the puerperium were found to exhibit still a high fat content and by the end of this time, the patient's general health was such as to allow her to be discharged from the hospital. One patient, who consented to remain in the hospital 3 weeks, was found to have a lowered fat content of her white blood cells 21 days postpartum.

Of the component lipids, phospholipid followed, in general, the course outlined for total lipid, i.e., little or no change until the time of lactation and then a marked increase, as high as 600 per cent in some cases, toward the end of the first week in the puerperium. In Case 1, studied for 3 weeks, the last observation indicated the phospholipid value was beginning to return to normal in 21 days postpartum. In Cases 8, 10, and 11 the phospholipid value fell in the early days of the puerperium but subsequently toward the end of the first week an increase was registered.

Free cholesterol closely paralleled phospholipid throughout the fluctuation. The increases in free cholesterol were not as extensive, however, and seldom exceeded 200 per cent. In Cases 3, 10, and 11 there was again a fall in value in the early days of the puerperium with a subsequent increase in the cholesterol content. By 3 weeks postpartum (Case 1) free cholesterol had also begun to fall to within non-pregnant limits.

On the other hand, cholesterol ester showed little consistency in its behavior. The amount of cholesterol ester in the white blood cells at the termination of pregnancy is low. Following parturition about one-half the cases exhibited the addition or subtraction of a few milligrams per cent ester cholesterol, changes which are of little significance when considered in conjunction with the possible experimental errors. In Cases 1 and 11 ester cholesterol was raised by the seventh day postpartum, while in Cases 6 and 10 it was lowered. There appears, therefore, to be no relation between the postpartum state and the cholesterol ester content of the white blood cells, the lipid having a low value in the majority of cases.

An apparent discrepancy may be noted in Table I in that the value for total cholesterol in a number of cases does not represent the sum of the free and ester cholesterol. This is due to the fact that the method for total cholesterol determines 90 to 95 per cent of the lipid present, while that for free cholesterol determines 95 to 100 per cent. Thus where all the lipid present is in the form of free cholesterol, the figure for total cholesterol may be less than that for free cholesterol, an apparent mathematical paradox. However, since the arithmetical difference is rather insignificant, it has been considered more accurate to use the actual experimental figures for total cholesterol rather than multiply these by a factor to account for the 0 to 10 per cent loss of the lipid not accounted for by the experimental procedure. While these limitations of the method are admitted, it should be emphasized that of the various procedures available for the estimation of total cholesterol, the digitonin oxidation micro-method as herein used is probably the most accurate.

Following parturition there occurred a consistent rise in neutral fat except in Case 11 in which neutral fat fell in value. At the termination of pregnancy neutral fat is present in relatively small amounts in the white cells. The day after delivery neutral fat began to rise, in many cases markedly so, and the raised values persisted for 2 weeks. This increase in neutral fat may be interpreted as

representing the function of the white blood cells in transferring fat from the involuting uterus to the fat depots.

INTERPRETATION

The interpretation of the changes in fat metabolism of the blood leucocytes before and after parturition in women offers many difficulties. There are a variety of factors concerned and as these have not been fully investigated to date, it is not possible to state at the present time to what alteration in body physiology and pathology the changes noted are due. During normal uncomplicated pregnancy no extraneous factor need be considered in interpreting the lipid analysis of the white cells but, as has been shown, there is no significant variation in the lipid composition of the blood leucocytes during pregnancy from those of the non-pregnant woman. Following parturition, however, a number of factors may affect the lipid composition of the blood leucocytes. In the early days of the puerperium there may be a residual effect from the strenuous exercise, excitement, pain, and anæsthetic of labor. This is later followed by possible effects from the involuting uterus, injuries acquired during parturition, lactation, and the altered general metabolism ensuing after delivery of the fetus. These factors in turn open up new fields in the functions of the white blood cells and will be considered in future publications.

Whereas the significance of the white cell reaction following parturition remains at present obscure, the experimental analyses of their lipid content may be interpreted in the light of our present conception of the relation of lipid composition to functional activity. Briefly, in most cases there occurs, following parturition, an increase in phospholipid, free cholesterol, and neutral fat in the blood leucocytes. Cholesterol ester exhibits no consistent trend, some cases showing increased values and others lower values; little cholesterol ester was found present in the leucocytes at any time. Age, parity, loss of blood during parturition, length of labor, and extent of perineal lacerations were apparently not factors.

Apart from the increase in neutral fat which, as stated above, may be due to transport of fat by the leucocytes from the involuting uterus, the findings of increased phospholipid and free cholesterol with low values for cholesterol ester correspond to those noted by Bloor, Okey, and Corner (2) as indicative of activity on the part of a tissue.

The earlier suggestive and circumstantial evidence in this connection has been aptly reviewed by these authors who then proceeded in a series of excellent studies to demonstrate directly the relation of lipid composition to functional activity. Selecting a tissue, the corpus luteum of the sow, which passes through a well recognized cycle of activity and quiescence, they simultaneously made estimations of the lipid content and histological examination of sections removed from the same material (the results of which were separately published), studying the gland throughout its cycle in estrus and pregnancy. At the same time they made a similar study of the uterine endometrium (27) but as this tissue in the sow undergoes much less change during estrus and pregnancy than in other animals and in women (menstruation and pregnancy) the results obtained, although of the same nature, were not of the same extent nor as striking as those with the corpus luteum. Seven to eight days following rupture of the graafian follicle the corpus luteum of the sow has reached a high plateau of functional activity as indicated by a solid consistency and the appearance of fully differentiated cells. At or about this time lipid analysis reveals (a) a great increase in phospholipid (300 per cent), (b) an increase, less marked (66 per cent), in free cholesterol, (c) no change in cholesterol ester, and (d) variable but low values for neutral fat. From the seventh to the fourteenth day the corpus luteum is at the peak of its activity and lipid analysis exhibits no change from that at the seventh to the eighth day. Following the fourteenth day, however, if pregnancy does not occur, retrogression sets in. This period is characterized by (a) a fall in phospholipid, (b) no change in free cholesterol, (c) a great increase in cholesterol ester, and (d) a marked increase in neutral fat.

Comparing the lipid changes of active tissue, as noted above, with the lipid changes in the white blood cells during the middle and latter

part of the first week postpartum reveals that the essential features are similar in each case. Bloor, Okey, and Corner stress that the significant lipid variation that sets in when a tissue becomes active is an increase in phospholipid and low values for cholesterol ester. As already described, from the third to the seventh day postpartum, the phospholipid content of the blood leucocytes is increased in most cases while cholesterol esters are present in small amounts. Free cholesterol is also slightly increased, as in active corpus luteum tissue, but in addition neutral fat is increased, while in active tissue Bloor, Okey, and Corner found this lipid low in value. It may be, as noted above, that this increase in neutral fat is due to a scavenger action of the white blood cells following delivery. The relation of neutral fat to "activity" has not been stressed by Bloor, Okey, and Corner and on the basis of their hypothesis it is justifiable to conclude that beginning about the onset of lactation there occurs an increased activity on the part of the white blood cells in women. To what this activity is due has not been established but several possibilities at present under consideration have been discussed herein

The activity of leucocytes has been investigated in a different manner by Soffer and Wintrobe. By determining the oxygen consumption and glucoslytic function of the cells *in vitro*, they were able to show that mature and immature cells had identical activity but that granulocytes were more active than lymphocytes. While there are relatively more granulocytes in the blood of women following parturition, the percentage increase is much less than the percentage increase in phospholipid. Hence it does not appear that the altered lipid composition of the white blood cells may be ascribed simply to a relative increase in polymorphonuclear leucocytes. Rather there seems to be an altered fat metabolism of the leucocytes in general at this time.

Toward the end of pregnancy there exists a compensated acidosis and some degree of simple anæmia in most subjects. Both of these conditions have been stated to have a depressing effect on the activity of white cells (18, 22). In the present series of cases of pregnancy near term those whose white blood cells contained over 1 per cent phospholipid had a higher blood hæmoglobin value than those containing less than 1 per cent phospholipid substantiating to a certain degree the relation between white cell activity and anæmia. On the other hand, there appeared to be no relation between acidosis, as estimated by blood carbon dioxide determinations, and the phospholipid content of the white blood cells.

SUMMARY

The lipid content and distribution in the white blood cells of 11 women at or near the termination of pregnancy, during lactation, and the puerperium has been studied under controlled conditions of diet and exercise. It was found that age and parity did not affect the level of lipids in the leucocytes.

Before parturition the white blood cells have a wide range of lipid values though, on the average, cholesterol ester and neutral fat are low in amount and the total lipid content is reduced by about one-quarter from the mean levels in non-pregnant women.

Following parturition there is no change in the lipid composition of the blood leucocytes until the third to the seventh day. Then there occurs a rise in total lipid due to increases in phospholipid, free cholesterol, and neutral fat. These high values appear to return to normal beginning about 3 weeks postpartum. Cholesterol ester is present in small amounts throughout.

On the basis of current theory these results have been interpreted as indicating an increased activity on the part of the white blood cells during the first 2 to 3 weeks of the puerperium. The causes of this phenomenon have been discussed and a short review of the physiological chemistry of the blood leucocytes included.

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BACTERIOLOGY OF CHOLECYSTITIS

The Virulence and Spore Formation of Clostridium Welchii[1]

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PREVIOUS to the work of Rosenow, cultures from diseased gall bladders were made from the bile. Rosenow demonstrated that streptococci were found with greater frequency in the wall of the gall bladder than in the bile. In experimentation on animals, he reproduced cholecystitis in rabbits and in dogs by intravenous injection of freshly isolated strains of streptococci derived from patients with cholecystitis; but he was not successful in reproducing cholecystitis in animals by injecting these strains directly into the lumen of the gall bladder. On the basis of these experiments he concluded that infecting organisms reached the gall bladder by way of the arterial blood. Rosenow also produced cholelithiasis experimentally by the same method. Nickel and Judd repeated this work. The work of Wilkie and his associates confirmed that of Rosenow regarding the etiological importance of hæmatogenous infection and elective localization of streptococci in cholecystitis and cholelithiasis. Wilkie and associates also found that the cystic lymph node harbored the streptococci in a high percentage of cases.

In recent years much attention has been given to infection of the biliary tract by Clostridium welchii. Ellis and Dragstedt have shown that apparently normal, healthy livers of adult dogs frequently harbor Clostridium welchii. Andrews, Rewbridge, and Hrdina demonstrated that if the contents of the gall bladder of a dog were drained into its pelvis or thoracic cavity, severe gas gangrene developed. Andrews and Hrdina have pointed out that frequently in cases of acute, fulminating cholecystitis, the portion of gall bladder adjacent to the liver is more thickened and œdematous. From this they concluded that there was primary hepatitis, with direct extension to the gall bladder.

The presence of Clostridium welchii in infection of the gall bladder has been noted occasionally by many observers. Rosenow isolated this organism six times in a series of 48 cases and in a photomicrograph illustrated the presence of one organism in the wall. Gordon-Taylor and Whitby reported that Clostridium welchii was present in the gall bladder in 9 per cent of 50 cases in which cholecystectomy was performed, and that it was recovered in 13 per cent of a series of cases in which necropsy was performed.

The purpose of this study, aside from investigating the frequency with which the various infecting organisms are found in excised material and from confirming the etiological importance of streptococci, was to determine the relationship between the cultural characteristics and virulence of Clostridium welchii isolated from gall bladders in cases in which cholecystectomy had been performed and from various postmortem materials.

The method of taking cultures from surgically excised gall bladders was essentially the method described by Rosenow. The gall bladders were immediately taken to the laboratory in a sterile covered container. The bile was first aspirated for culture; then the gall bladder was opened and strips of mucosa with submucosa were excised; these were washed three times in sterile saline solution and finally ground in a mortar, together with a small amount of sand and saline solution. This material was plated on blood agar and also was put in glucose brain broth, the latter medium being especially favorable for the growth of streptococci and Clostridium welchii.

When a suitable growth of streptococci was obtained in the primary cultures from human gall bladders, reproduction of cholecystitis was attempted in rabbits. The rabbits were given an intravenous injection, 0.5 cubic centimeter for each 100 grams of body weight, of a fresh culture of streptococci in glucose brain broth, on two successive days. They

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were killed on the fourth day after the first injection.

For identification of Clostridium welchii, materials were put in Blair-Wilson medium to elicit the black, iron sulphide reaction, also on anaerobic blood agar plates, to determine the type of colony, and in tall tubes of sterile milk, to elicit coagulation, with its stormy fermentation and the characteristic odor of butyric acid. Following this, smears of the cultures were stained by Gram's stain, counterstained with safranin, and studied microscopically for evidence of spore formation in cultures containing Clostridium welchii. The heat test for spore formation was used with cultures in plain broth, in plain broth with coagulated egg white, and in plain broth with 1 per cent plain starch.

In instances in which Clostridium welchii had been identified by the foregoing methods, the 24 hour cultures of the same material in glucose brain broth, in which they were grown, were injected intramuscularly in doses of 3 cubic centimeters, into rabbits, guinea pigs, and pigeons to determine their virulence, the breast muscles of the pigeons being most highly sensitive and the thigh muscles of the rabbits being the least sensitive to pathogenic strains. As a final test of pathogenicity, rabbits were given 10 cubic centimeters of the same cultures intravenously.

Since the results of the preliminary experiments suggested association of low virulence with loss of spore-forming ability, further studies were carried out. Virulent cultures of Clostridium welchii were obtained from material at necropsies on human subjects, and pure strains were selected from colonies grown under anaerobic conditions on blood agar plates. First, an attempt was made to produce *in vitro* a decrease of virulence and loss of ability to form spores, by subjecting the organisms to the action of fresh and autoclaved bile in various concentrations, and then testing their virulence in animals and spore-forming ability on special media. These results being negative, experiments were performed on animals. Rabbits were given injections of six virulent strains, which were kept in plain broth with bile as controls, in sublethal doses, into the muscles of the right hind leg, and guinea pigs were given 3 cubic centimeters in like manner. The resulting death of the guinea pigs, and of about half of the rabbits, proved the virulence of the strains in question. On successive days following the injections into the rabbits, a sterile needle attached to a syringe was inserted aseptically into the regions where Clostridium welchii had been injected, 0.5 cubic centimeter of sterile physiological saline solution was injected, and a small amount was aspirated and cultured. As a routine, on the tenth day, the rabbits, immediately after being quickly killed with chloroform, were subjected to necropsy, and cultures were made again, from the muscles of the leg at the site of former injections, the regional lymph nodes, and the heart's blood. The cultures of Clostridium welchii thus obtained from the rabbits were again tested for spore formation and pathogenicity in guinea pigs.

The determinative bacteriological investigations of sections excised surgically from the walls of human gall bladders in 75 cases yielded the following results. In 30 cases the sections were sterile, streptococci were found in 13 cases, staphylococci in 26, bacillus coli in 6, diphtheroids in 5, and Clostridium welchii in 5. Human bile from 59 cases was investigated; it was sterile in 50 cases, contained streptococci in 7, staphylococci in 1, Bacillus coli in 1, Bacillus subtilis in 1, and Clostridium welchii in 1. In 25 cases of gall stones in man the concretions were sterile in 15 cases, contained streptococci in 5, staphylococci in 3, Bacillus coli in 4, Bacillus subtilis in 1, and Bacillus pyocyaneus in 1. Specimens of surgically excised liver were investigated in only 2 cases and staphylococci found in 1. The gall bladders of 9 dogs were examined; in 4, the wall contained Clostridium welchii, and in 3, the bile was likewise infected.

These results from the primary cultures indicate a lower incidence of infection than has been reported by Rosenow and others. This is probably due to the fact that in this series there were few acute cases. The incidence of infection in the wall of the gall bladder from human subjects was found to be four times greater than in the bile, and two

and four-tenths times greater than in the gall stones. It was found also that the wall was relatively more often infected with virulent streptococci. The wall always contained streptococci when the bile did. Microscopic sections of the fundus of the ball bladders revealed a higher incidence of cholecystitis in gall bladders which were infected with streptococci.

Seven strains of streptococci, isolated chiefly from walls of gall bladders, were used for experiments in elective localization. In these experiments the organism was a rather plump diplococcus that grew in glucose brain broth within 24 hours. This growth was in sharp contrast to that of some of the less virulent strains of streptococci, which required from 5 days to a week to grow. With one strain of plump diplococcus, cholecystitis was produced electively in each instance, and the organism was recovered from the bile or wall of the gall bladder of rabbits through four successive animal passages. The organisms isolated in each instance were from the content or exudate within the gall bladder. Although this strain of streptococcus was occasionally recovered from the kidney or spleen, it did not produce cholecystitis when the organism was isolated from these sources. In the 6 other cases, gross cholecystitis, with recovery of streptococci from the bile or wall of the gall bladder, was produced in 4.

Clostridium welchii was isolated from the wall of the gall bladder in man in 5 instances, or 7 per cent of cases, and from the bile in 1 instance, or 1.6 per cent of cases. In only one acute, fulminating case in man and one case in the dog, was Clostridium welchii isolated from the gall bladder, which on injection into rabbits, guinea pigs, and pigeons proved to be virulent and formed spores on suitable media. In all other instances non-virulent and non-sporing, large, gram-positive bacilli resembling Clostridium welchii, which gave the typical reaction on Blair-Wilson media, the fermentation and coagulation of milk with the odor of butyric acid, and the type of colony on anaerobic blood agar plates characteristic of Clostridium welchii, were found in the walls and bile of gall bladders which appeared, grossly, as normal. There was, however, histological evidence of low grade inflammatory change in the walls of the gall bladders in 2 cases in which Clostridium welchii was associated with streptococcal infection and in 1 case associated with Bacillus coli. In the other cases Clostridium welchii was the only organism isolated, and there was no histological evidence of infection. In dogs infected with Clostridium welchii, tetrad organisms were associated.

Eight rabbits survived injection into the right hind leg, of 3 cubic centimeters of a virulent 24 hour culture of Clostridium welchii in glucose brain broth, representing six virulent strains obtained from material at necropsy. Cultures from the lesions were made on successive days. The isolated organisms were invariably pathogenic for guinea pigs, and were able to form spores that were heat resistant to 80 degrees C. for 15 minutes, until the fifth or sixth day. Following this, although the cultures were still positive for Clostridium welchii microscopically, were characteristic in Blair-Wilson media, also as to type of colony on anaerobic blood agar plates, and on milk media produced fermentation and coagulation with the odor of butyric acid, they simultaneously had lost their ability to form spores and their high virulence. The control cultures kept in plain broth plus bile retained their high virulence as well as their spore-forming ability throughout the duration of the experiments.

Aspirated material from these rabbits became sterile on the eighth day in 2 cases and on the ninth day in 1 case, and then, at necropsy on the tenth day, cultures from the excised muscle, regional lymph nodes, and heart's blood were likewise negative. In the other 5 rabbits, local abscesses developed. These contained cheesy material from which large gram positive bacilli were isolated every day and at necropsy on the tenth day, but cultures from the heart's blood and regional lymph nodes proved sterile. These large gram positive bacilli isolated from this cheesy material and from local lesions in other rabbits in which abscesses did not develop after the fifth and sixth days, gave the typical reactions for Clostridium welchii in the Blair-Wilson and milk media, and typical colony on

anaerobic blood agar plates. These organisms, however, failed to form spores on suitable media, and proved to be of low virulence when 5 cubic centimeters of 24 hour glucose brain broth cultures were injected into the muscles of the hind legs of guinea pigs.

EVALUATION

The source of Clostridium welchii found in gall bladders is generally conceded to be the intestinal tract, and it is believed that the organisms reach the gall bladder either from the portal system or by ascending through the ducts. Judging from the results of studies of the pathogenicity and spore formation of organisms obtained from man as well as from animals, it is believed that this organism is of the nature of a secondary invader and seldom is primarily the cause of cholecystitis. Further, it appears from the results obtained that a healthy person is able to reduce Clostridium welchii to a state of low virulence as well as inability to form spores.

Attention may be called to the fact that these rabbits were apparently well, were subjected to necropsy after being quickly chloroformed, and the examination was made immediately, thus eliminating the possibility of agonal or postmortem invasion, and this possibly accounts for the frequent negative cultures as contrasted with the results of Cornell, in whose work the rabbits became very ill, had convulsions, and died spontaneously. It is also important to note that Cornell worked with entirely different strains of Clostridium welchii which he isolated from fæcal material.

The question may be raised as to how these organisms could be Clostridium welchii when they did not form spores. In answer to this, attention may be directed to the fact that seldom does a high percentage of organisms in any culture of Clostridium welchii form spores, and that total loss of spore formation is not a new phenomenon in bacteriology, since Pasteur, Rous, Lubarsch and others, as described by Sternberg, have reported similar changes for Bacillus anthracis. The work of Weinberg and Séguin during the World War, established the fact that the virulence of Clostridium welchii varied considerably in different cultures.

CONCLUSIONS

1. This work, in the main, supports the fundamental work of Rosenow regarding focal infection and elective localization.

2. It demonstrates that Clostridium welchii, as commonly isolated from the gall bladder of man at operation for cholecystitis, and from gall bladders of healthy dogs, is of low virulence as well as being non-spore-forming. Markedly lowered resistance of tissues appears to be a prerequisite for maintenance of virulence and spore-forming ability of this organism *in vivo*.

3. Virulent and spore-forming Clostridium welchii may be injected into the leg muscles of the rabbit and, although healing occurs, may be recovered after about the sixth day in a state of low virulence and without ability to form spores, while control cultures *in vitro* retain their high virulence as well as their ability to form spores.

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BLOOD AMYLASE IN EXPERIMENTAL PANCREATITIS

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QUANTITATIVE determinations of diastatic ferments in the blood were first made by Wohlgemuth in 1908. His method depends for its endpoint on the complete hydrolysis of soluble starch as revealed by the disappearance of the blue color, which it produces with iodine. The newer method of estimating blood amylase content depends upon the determination of viscosity of starch solution which changes with molecular cleavage. This method has been brought to a high state of perfection through the modification of the Davison technique (6, 13) by Elman and McCaughan (8). With the present technique, a definite quantity of clear blood plasma and a standard starch solution are mixed in an Ostwald viscosimeter, which is submerged in a water bath at constant temperature. Viscosity is determined by the time required for a definite amount of this mixed fluid to pass through the capillary portion of the viscosimeter tube, which occurs with a speed proportional to the amount of amylase present. This change in viscosity is an index of the amount of amylase present in the blood plasma.

For nearly 10 years quantitative determinations of blood amylase have been made, and during this time an extensive literature has accumulated, yet the source, distribution, and function of blood amylase remain largely obscure.

The function of circulating blood diastases, which are formed by organs producing glycogen, according to Cohen, is intimately associated with the splitting in the liver of glycogen to sugar. Cohen further states that diastases become active only when in the tissues. According to Reid and Narayana, increased blood amylase means a decreased activity in the liver of that animal. Also, a decreased blood amylase (or increased tissue amylase) signifies increased activity in the liver. Carlson and Luckhardt, and Markowitz and Hough believe that blood and lymph amylase are functionless, being by-products of organ metabolism, which appear in the blood for destruction or elimination. On the other hand, Huber and Macleod found that a glycogen-like polysaccharide exists in the liver sinusoids and sublobular veins of the diabetic rabbit, and believe that the function of blood amylase is to assist in the hydrolysis of this glycogen. Myers and Reid conclude that amylase, while in the blood, plays no rôle in carbohydrate metabolism and that only when in the presence of insulin is it recalled or reabsorbed into the liver cells where it exerts its enzymatic function with regard to the glucose glycogen reaction.

Elman, Arneson, and Graham, in studies on human blood, say that low blood amylase means destruction of acini in the pancreas, whereas increased blood amylase means duct obstruction. With duct obstruction, there is increased absorption of pent-up ferments into the blood without atrophy of the acini. According to these authors, inflammatory processes in chronic pancreatitis probably lead to obstruction of smaller ducts by scar tissue. In acute pancreatitis, there is an abnormal absorption of ferments into the blood because of changes and destruction of the walls of the ducts so that the secretion, instead of flowing on into the duodenum, makes its way into surrounding tissues and thence into the blood and lymphatics. Jorns obtained high amylase values in the pancreatic tissue early in experimental mild acute pancreatic necrosis, which values soon dropped below normal, and in severe necrosis there was immediate diminution of tissue amylase. Also, following ligation of the pancreatic ducts, there was an immediate postoperative rise in the pancreatic tissue amylase with a rapid fall to normal. He concluded that in duct ligation there was an early rise of diastase in the pancreatic tissue, the direct result of stasis. In severe pancreatic necrosis, there was a diminution of amylase in the pancreatic tissue, which he says means

TABLE I.—BLOOD AMYLASE VALUES IN PANCREATITIS PRODUCED BY THE INJECTION OF STERILE GALL-BLADDER BILE INTO THE DUCTUS SANTORINI

Dog 1		Dog 2		Dog 3		Dog 4	
Days before and after operation	Blood amylase units	Days before and after operation	Blood amylase units	Days before and after operation	Blood amylase units	Days before and after operation	Blood amylase units
0	15	0	25	0	15	0	26
1	100	1	86	1	150	1	200
2	200	2	66	2	150	2	200
3	120	3		3	150	3	200
4	75	4	66	4	100	4	
5	25	5	29	5	40	5	150
6	25	6				6	120
7	14	7				7	80
8	13	8	17				
9	13	9	29				
10	13	10					
12		11	29				
14	17	12					
16							

destruction of the quantity of ferment with failure of new ferment formation. Crandall and Cherry found in dogs an immediate increase in blood amylase after ligation of the common bile duct with double the normal value on the second to the fourth day. They also found in dogs that when pancreatic juice was injected intravenously amylase was increased in quantity in the portal and saphenous veins. It was their interpretation that blood amylase was only partially removed by the liver.

The various investigators, using the viscosity method, have not established any definite level in absolute units for the starch splitting enzyme content in the plasma of normal dogs. Each found that a normal range can be established with his own particular method. According to Chesley, this probably is caused by the variable composition of the different starches used. He observed that starch used as a substrate does not have a uniform composition, as it is made up of several substances, namely, alpha amylose (amylocellulose, amylopectin), beta amylose (amylose, amylodextrin), and dextrins. Different batches of starch have variable amounts of α and β amylose, hence different results are obtained with different batches. Elman and McCaughan, using 7 per cent starch, found values for normal dogs to be between 1.5 and 2.5 units; whereas Johnson and Wies found normal values to be 6 to 13 units. Myers and Reid obtained values of 14.6 and 19.4 or an average of 17 units. Cohen, using 7 per cent starch, found normal values to be between 12 and 67 units, with an average of 37. We found values (viscometric method) for 69 normal dogs, using 0.1 cubic centimeter clear blood plasma and 3 per cent Lintner's starch solution, to be 20 to 56 units, with an average of 36. The unit determination varied slightly with different batches of Lintner's starch. Johnson and Wies found in 4 animals, that when the pancreatic ducts were ligated, the amylase concentration of the serum increased from 9 to 20 times normal to reach a maximum on the third day after operation. Following this, there was a gradual decline to approximately normal on the twelfth day after operation. Reid *et al* (16, 17) found in dogs after pancreatectomy, if kept alive with insulin, that there is a decrease in blood amylase for a few days, then a rise to normal or to a point higher than pre-operative level. When insulin was stopped the amylase again dropped. Reid and Narayana noted that insulin lowers blood amylase but increases liver amylase.

TABLE II.—BLOOD AMYLASE VALUES IN PANCREATITIS PRODUCED BY THE INJECTION OF ETHER INTO THE DUCTUS SANTORINI

Dog 1		Dog 2		Dog 3	
Days before and after operation	Blood amylase units	Days before and after operation	Blood amylase units	Days before and after operation	Blood amylase units
0	20	0	25	0	26
1	300	1	250	1	300
3	300	2	135	2	300
4	170	3	60	4	300
6	100	4	60	5	350
7	60	8	24	6	120
8	40	11	24	7	120
9	48	15	16	8	75
10	48	27	14	9	63
11	30	39	19	11	48
				13	150
				14	200
				17	150
				20	20
				24	16
				25	20

From these citations, it is apparent that there is a wide divergence of opinion as to the source, distribution, and function of blood amylase. In addition, there is not even a close parallel in results as to the amount of amylase present in the circulating blood of normal dogs. While the methods of determination have been brought to a high state of perfection, standardization apparently is lacking.

METHODS

Since temperature reaction and salt concentration affect the viscosity, they must be controlled and kept uniform. A temperature of 37.5 degrees centigrade does not affect stability of amylase; hence, this temperature is used throughout the experiments. Three per cent sterile buffered starch solution (Lintner's) was used as a substrate (6). It will keep indefinitely if kept sterile, thus obviating the necessity of preparing fresh material each time. Values for amylase are expressed in units that indicate a quantity of amylase that will effect in 1 hour a change of 20 per cent in the viscosity of 5 cubic centimeters of a 3 per cent buffered starch solution. Venous blood (fasting) was collected in oxalate solution and examined within 2 hours. To 3 grams of Lintner's starch, sufficient buffer solution (Ph. 7) is added to make 100 cubic centimeters. This is boiled for 1 minute over a free flame and autoclaved at 18 pounds pressure for 15 minutes. It is then filtered through paper or cotton and kept sterile. All pipettes and viscosimeters are plugged with cotton to prevent contamination with saliva. Five cubic centimeters of the starch solution is added to an Ostwald viscosimeter and placed in a glass water bath at 37.5 degrees centigrade. The temperature is kept constant with an electrical control. Several determinations of the viscosity of the starch solution are made with a stop watch. The time required for 5 cubic centimeters to flow through the capillary tube is noted, which is the viscosity time of the solution. Clear blood plasma (0.1 cubic centimeter) is added and the time is noted. Readings are made every 3 minutes until the viscosity shows a reduction of 20 per cent as previously calculated. One amylase unit is defined by Davison as the amount of enzyme which will accomplish this change of viscosity in 1 hour. In other words, one unit of amylase is that amount of enzyme which requires 60 minutes to reduce the initial viscosity 20 per cent.

Example: If 0.1 cubic centimeter of clear blood plasma or enzyme solution should cause a reduction to 80 per cent of the original viscosity in 15 minutes, the 1 cubic centimeter of the solution would contain $\frac{(60 \text{ min.} \times \text{vol.})}{\text{Time in min.}}$ or $\frac{60 \times 10}{15}$ equals 40 units of amylase per cubic centimeter.

In a previous paper (3) we noted the blood chemical changes in experimental acute pancreatitis. Five different solutions were utilized in these experiments. Infectious solutions, sodium taurocholate, sodium salicylate, ether and gall-bladder bile were injected into the ductus Santorini. The degree and extent of the inflammatory reaction which they produced was determined by complete pathological studies. It was found that the inflamma-

tory reaction was greater with solutions of Bacillus coli and least with sterile gall-bladder bile. The same solutions were used in the following experiments.

OBSERVATIONS

The most violent inflammatory reaction was found to be produced by the injection of infectious material. Following the injection of a saline suspension of Bacillus coli or a suspension of Bacillus coli in bile, an astounding rise in blood amylase was observed. In one instance, it reached as high as 1200 units. This amounts to 30 times normal. Sodium taurocholate produced a pathological lesion next in severity to infectious material. Following its injection into the pancreas the blood amylase value rose to 800 units which did not return to normal in 13 days. Diethyl ether produced acute pancreatitis which pathologically was not as severe as that produced by sodium taurocholate. Here the pancreatitis was accompanied by a rise in blood amylase to 350 units which remained high for several days. The injection of sterile gall-bladder bile was not as reactive as any of the above, but was accompanied by a rise in blood amylase, which reached a maximum figure of 200 units and persisted from 2 to 6 days before returning to normal.

We have compiled our data in tabulated form, which is self explanatory.

TABLE III.—BLOOD AMYLASE VALUES IN PANCREATITIS PRODUCED BY THE INJECTION OF SODIUM TAUROCHOLATE INTO THE DUCTUS SANTORINI

Dog 1		Dog 2	
Days before and after operation	Blood amylase units	Days before and after operation	Blood amylase units
0	40	0	40
1	660	1	480
3	600	2	600
4	800	3	600
5	480	4	800
6	800	5	300
7	300	6	480
8	600	7	300
10	800	8	115
11	270	10	115
14	21	13	70
18	27	26	40
21	60		
31	66		

EVALUATION

Our studies have been made on dogs, thus permitting controlled experimental procedures and observations. In every instance, the pancreatic ductus Santorini was injected and ligated with silk. In addition, many acini of the pancreas were damaged so that from the beginning the combination of duct obstruction and acinar destruction was present. This condition persisted until autopsy.

From these observations, it is apparent that experimental acute pancreatitis in dogs is immediately accompanied by a sharp rise in blood amylase. Also this rise in amylase is proportional to the severity of the lesion. It is further apparent that this rise is only temporary, as in every instance except when infectious material was injected, the blood amylase approached a normal figure before the animal was sacrificed, and yet in each instance a severe pancreatic inflammatory reaction persisted after the amylase returned to normal value.

In the light of the present available facts, several different explanations of the phenomenon are possible. We possess insufficient information to separate these possibilities. Temporary increase of blood amylase immediately accompanying acute inflammatory lesions of the pancreas may be due to the manufacture by the pancreas, of excessive amounts of amylase which overflow into the blood. This would seem plausible, but just why this excessive amylase concentration of the blood should return to essentially a normal figure while active acute inflammatory reaction remains in the pancreas is more difficult of comprehension. It might be explained by either a failure of the pancreas to continue the manufacture of excessive quantities of amylase, or it might be that mechanisms are set in motion which filter out these excessive amounts of amylase practically as fast as they are formed, so that after they have adapted them-

TABLE IV.—BLOOD AMYLASE VALUES IN PANCREATITIS PRODUCED BY THE INJECTION OF BACILLUS COLI INTO DUCTUS SANTORINI

Dog 1		Dog 2		Dog 3		Dog 4		Dog 5	
Days before and after operation	Blood amylase units	Days before and after operation	Blood amylase units	Days before and after operation	Blood amylase units	Days before and after operation	Blood amylase units	Days before and after operation	Blood amylase units
0	24	0	12.8	0	28	0	40	0	42
1	600	1	240	1	800	1	1200	1	800
2	600	2	220	2	480	2	800	2	800
3	600	3	100	3	350	3	600	3	600
4	600	4	40	4	400	4	260	5	200
6	600	6	27	6	480	6	46	7	150
7	200	9	30	7	480	8	70	9	340
8	200			8	660	9	63		
9	300			10	85	10	57		
11	240			11	85	11	40		
14	240			17	45	13	44		
15	400					16	43		
16	400					18	40		
18	600					21	50		
21	170					32	38		
22	100					36	54		
26	92								
27	100								
30	85								
43	100								
53	170								

selves to the new circumstance of the acute inflammatory reaction in the pancreas the blood amylase is held at an essentially normal figure. The interrelationship between insulin and amylase in carbohydrate metabolism has been stressed by Myers and Reid and others. Acute diffuse pancreatitis, such as we have produced, undoubtedly has involved the islands of Langerhans. With the insulin forming tissue thus involved, we have an additional factor for consideration.

Our evidence would lend support to the views of Elman. It may very well be that the explanation for the return to normal of the blood amylase is the deposition of fibrous tissue along with other factors, which tend to wall off the inflamed areas and which occur after the lesion has existed for a time. Although Jorns is of the opinion that in high grade tissue destruction or increased stasis of long duration, the ferment is either destroyed or there is cell failure in its formation. We are not prepared at this time to interpret the observed facts definitely.

CONCLUSIONS

1. We have studied the blood of normal dogs, on which viscometric amylase determinations were made. With 3 per cent Lintner's starch solution as the substrate and using 0.1 cubic centimeter clear blood plasma, we find the normal amylase content to be 20 to 56 Davison units.

2. Injury of the pancreas is accompanied by a marked temporary rise in amylase. The more severe the injury the greater the rise in amylase.

3. Elevation of blood amylase is only transient and severe injury of the pancreas after the first week is accompanied by normal blood amylase, even though pathology of the pancreas persists.

4. Chronic injury of the pancreas is accompanied by normal or slightly increased blood amylase.

5. Degenerative changes, such as cloudy swelling and necrosis about the central vein in the lobules of the liver, were a constant observation. Pathological studies checking the degree of pancreatitis were made in all cases.

6. Blood amylase determinations are indicated clinically in determining early acute pancreatic pathology.

We desire to express our appreciation to Dr. C. J. Weber, director of the Research Laboratory at the University of Kansas, for his technical assistance in this work.

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CLINICAL SURGERY

FROM THE SURGICAL CLINIC, NEW YORK POST-GRADUATE HOSPITAL

CARCINOMA OF THE COLON

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IN any operative procedure for cancer of the colon, peritonitis stands out as the greatest danger and the most serious complication. In our operative procedure, the dangers of this obstacle have been greatly lessened as we do not clamp the bowel intraperitoneally nor do we cut the bowel with a knife or cautery thereby blocking any infection from the cut lumen into the general peritoneal cavity.

In preparing these patients for operation, a second important factor must be kept in mind, that is that they are suffering from reduced general health and strength due to advanced years and that they are often inflicted with some debilitating systemic disease. Consequently, the following steps must be taken: repeated blood transfusions must be given and, several days before operation, 3,545 cubic centimeters of glucose and saline solution should be administered along with a high caloric non-residue diet, and any obstruction should be relieved by repeated irrigations. The blood transfusions, the introduction of fluids, the use of a high caloric diet, and the cleansing of the bowel as much as possible by irrigations, increase the safety for the following operative procedures.

In all cases of cancer of the colon, I make a preliminary cæcostomy through the McBurney gridiron incision, as shown in Figures 1 to 4, the cæcum being drawn up as in Figure 5. A Paul's tube is introduced into the cæcum (Fig. 6), this step being delayed for 48 hours to insure proper walling-off. This tube, of course, drains away quantities of fluids which have to be replaced by intravenous injections of 5 per cent glucose, normal saline solutions, and also by clysis and repeated blood transfusions. The blood chemistry is closely watched. When the condition of the patient warrants it, he is sent home for a 2 months' rest before the radical abdominoperineal excision is performed. Upon re-entering the hospital, a complete check-up is again made. The administration of transfusions—glucose, saline—and the application of an indwelling catheter are ordere[d]. A median or left incision is made and the mese[n]tery of the left colon is resected, from a poi[nt] above the growth down through the peritoneal r[e]flection, the gland bearing area being excised as [in] Figures 7 to 9. The abdomen is then temporari[ly] closed. The patient is placed in the lithoton[omy] position for the perineal resection. The area [is] painted with iodine, gauze soaked with iodine [is] introduced into the rectum, and the apertu[re] is closed with a continuous suture. The perine[al] incision is made preferably with a cautery, as [in] Figure 11, and continued until sufficient rectu[m] extrudes so that a sterile rubber glove can com[-] pletely cover the lower bowel, as in Figure 12. Having dissected up to the peritoneal reflection, the abdomen is re-entered, the peritoneal reflec[-] tion dissected, and the entire loop is carried out[-] side the abdomen. Before this is done, a separate incision is made in the left rectus muscle and the entire vesicled bowel is carried through this aper[-] ture for the purpose of fashioning a single barrel colostomy. The peritoneal reflection is closed and the incision in the abdomen is also closed in the usual manner. The cut edges of the sigmoid mes[-] entery are sutured to the left parietal peritoneum to prevent herniation. The extraneous gut is double clamped a few inches from the colostomy opening and severed with a cautery, completing the single barrel colostomy. With these manipu[-] lations, there is very little chance of infection and peritonitis.

In those cases of tumor of the left colon [in] which the growth is resectable, it has always be[en] my contention that a modified Mikulicz and Pa[ul] operation is preferable. The old so called eventr[a]tion operation is seldom used at the present tim[e]; all criticism seems to be directed against the [old] procedure, however. The preliminary colostom[y] operation is performed and the patient is se[nt] home to recuperate. Two months later, the p[a]tient re-enters the hospital and a complete che[ck]

Fig. 1.

Fig. 2.

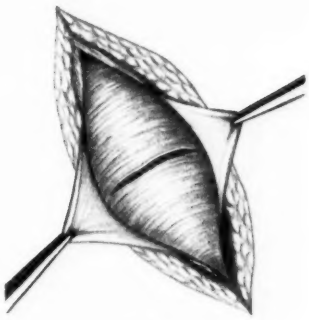
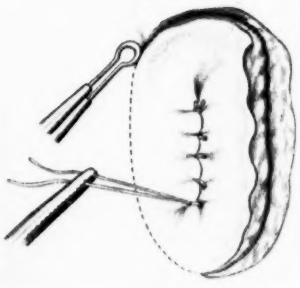


Fig. 3.



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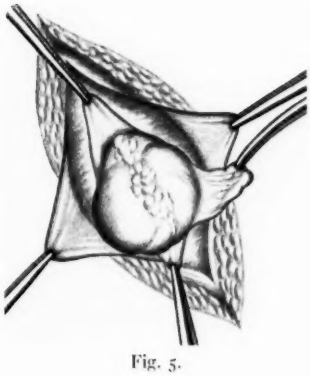

Fig. 5.

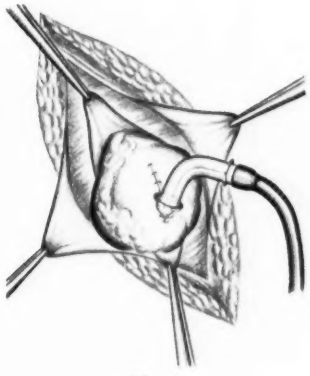

Fig. 6.

up is again made. The usual incision is made on the left side of the median line and the growth surrounded with laparotomy pads. Manipulation should be as gentle as possible while the incisions are made in the mesentery. The incision should be sufficiently long that the growth can be drawn well outside the abdomen and the two barrels of the colon approximated for a distance of 2.5 to 3 inches. The approximation is made by sutures through the cut edges of the mesentery; due care should be used to determine the viability of the approximated barrels by first determining the efficiency of the circulation. In dealing with carcinoma of the left part of the transverse colon and the left colon and sigmoid, we are able to draw more colon out of the abdomen if, first, we sever the phrenicocolic ligament fairly high up. Also, in sizing the peritoneal reflection on the outer or left side of the resected area we are enabled more readily to approximate the barrels of the colon.

In the newer Paul-Mikulicz type of operation, no sutures are used to approximate the parietal peritoneum with the colon proper. If it be necessary, however, the parietal peritoneum can be sutured to the cut edges of the mesentery. At the end of 72 hours, the tumorous mass can be resected with a cautery and the usual follow-up procedures of the Paul-Mikulicz operation can be accomplished without any undue haste.

By means of a continuous suction apparatus, we are better able to keep the wound clear of débris. With the preliminary cæcostomy and suction, faster healing is accomplished. This same operative procedure can be used for carcinomata of the transverse colon. When dealing with malignant growths in the right colon, however, I use the Paul-Mikulicz type of operation, the terminal ileum being used as one barrel and the hepatic flexure of the colon as the second barrel as has been suggested by Frank H. Lahey. In this latter procedure, I use a preliminary ileostomy about 12 inches or more proximal to the cæcum, and introduce a pezzer catheter which has been witzelized according to the Hendon technique. Thus, more

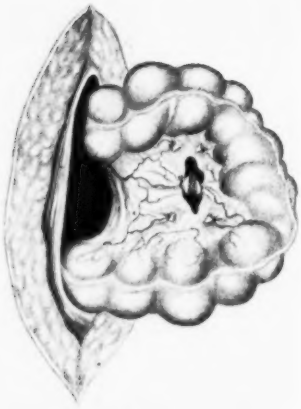

Fig. 7.

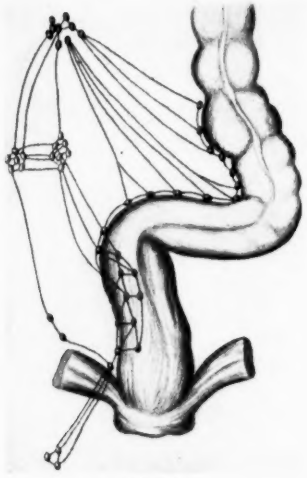

Fig. 8.

or less, continuous suction is applied to the catheter for the first 72 hours to avoid infection and suppurative wound edges.

In multiple malignancy of the right, or transverse, colon, or the left colon, the Paul-Mikulicz type of operation can be utilized with the terminal ileum as one barrel and the sigmoid as the other. If, for any reason, a preliminary cæcostomy is inadvisable owing to tremendous dilatation of the cæcum caused by the carcinomatous constricting growths where we might meet the Dehnungs-Geschwuere of Kocher with ischæmia or ulceration due to faulty blood supply, we then do a preliminary ileostomy using the Hendon technique.

The postoperative care of these patients is very important. While the patient is in the operating room, a continuous infusion of glucose, 5 per cen and normal saline solution is given. Upon the p tient's return, 4,500 cubic centimeters of the gl cose and saline solution are given by hypoderm clysis or venoclysis in each 24 hours. Arrang ments are made for blood transfusions to be give as required. In any case, one transfusion, aft operation, is always given. Parotitis is a compli cation which causes some anxiety but in recen years the early use of radium has had a mos favorable influence.

In all my cases, I have used an indwelling catheter and have used irrigations of boric acid after operation for at least 1 week. The patients are made comfortable by the use of morphia and the absence of any fluids by mouth for at least 48

Fig. 9.

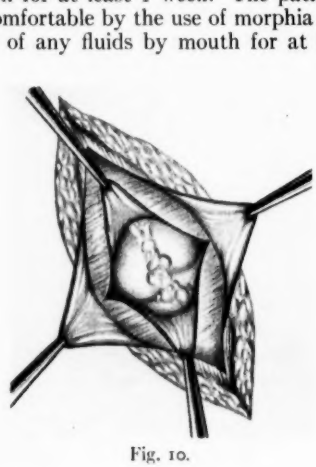

Fig. 10.

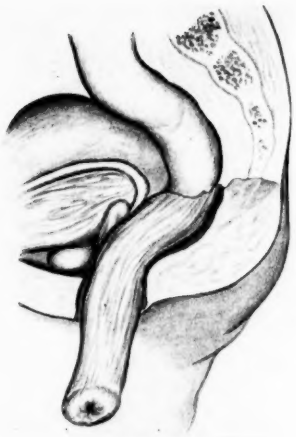

Fig. 11.

Fig. 12.

hours. The removal of the gauze pack from the peritoneum is facilitated by soaking the gauze pack with hydrogen peroxide and irrigations of normal salt solution. Special attention should be given by the attending surgeon to instruct the patient as to the care of the colostomy opening.

CONCLUSIONS

In the operative procedures described, not once have we used clamps or severed the colon by cautery as is done in all forms of anastomosis. Nor do we suture the colon wall to the parietal wall of the peritoneum. The mortality of colon surgery, as I have stated before, is still very high. In my opinion, it will always remain so if surgeons in general adopt any of the so called aseptic technique operative procedures which have been so carefully described. I believe that the term is a misnomer, as every time we apply clamps across the lumen of the colon, we traumatize the wall so severely that hordes of microscopic or ultramicroscopic bacteria are spilled into the peritoneal cavity. So infection and tension are the chief adverse factors of all colon operative procedures to date. In the operation that I have described, the mortality should be so much lower that I am sure its lack of danger will appeal to the careful and conscientious surgeon.

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REPAIR OF RECURRENT AND DIFFICULT HERNIAS AND OTHER LARGE DEFECTS OF THE ABDOMINAL WALL EMPLOYING THE ILIOTIBIAL TRACT OF FASCIA LATA AS A PEDICLED FLAP[1]

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FORTY years ago, in one of his early contributions to the operative treatment of inguinal hernia, Halsted began his remarks with the following quotation from Schuh, a Viennese surgeon of an earlier generation: "If no other field were offered to the surgeon for his activity than herniotomy, it would be worth while to become a surgeon and to devote an entire life to this service." Recognizing the limitations of surgery in the pre-antiseptic era, one may fully appreciate the significance of Schuh's statement.

In the remarkable treatise of Astley Cooper on hernia which appeared in 1804 the pathogenesis and anatomy of hernia were accurately described in a manner in accord with later day conception.

Operative efforts in the treatment of hernia, however, remained limited to the release of strangulation. Even the advent of anæsthesia and asepsis, the events of greatest consequence in the evolution of surgery, awaited the perfection of an adequate technique before surgery could offer sufferers from this malady promise of prolonged relief. In 1889, Bassini came forward with the description of his operation for the repair of inguinal hernia, which procedure together with contributions from numerous sources established permanently the worth of the operative method in dealing with hernia.

The passing years have indicated, nevertheless, that a number of cases remain refractory to the usual method of repair. The high incidence of recurrence of direct inguinal hernia repaired by the ordinary hernioplastic technique is indicated by every report in which the ultimate results are carefully scrutinized.

Thirty-two years ago McArthur utilized living sutures of fascia cut from and left attached to the adjacent edges of the incised external oblique aponeurosis to buttress and strengthen the hernia repair. Twenty years later Gallie and LeMesurier cut similar strips of fascia lata and brought the tissues in the groin together by a latticework of these free fascial strips woven back and forth, through and over the approximated structures. Already in 1909, Kirschner had demonstrated the ability of strips or sheets of fascia to survive independently when transplanted as autografts. The employment of these methods in the repair of recurrent and direct hernias has contributed materially to satisfactory and lasting results in the surgery of difficult hernias.

The operative procedure which the writer wishes to present is a new application of a well established principle in plastic surgery, viz., the transplantation of a musculotendinous structure with its nerve and blood supply preserved intact. The iliotibial tract may be readily swung up from the thigh into defects of the abdominal wall. This strong sheet of fascia is directly continuous with the tensor fascia lata muscle which takes origin from the crest of the ilium. The innervation and blood supply of this muscle come from the superior gluteal nerve and artery and reach the muscle from behind where they course over the fibers of the gluteus minimus muscle. The tensor fascia lata muscle may be employed as the pedicled support and base for the mobilized iliotibial tract. This circumstance together with the facility of transfer and lack of compromise of any important function performed by this tendinous structure in the thigh, eminently fits it for the repair of defects of the abdominal wall and particularly of the inguinofemoral region.

This method was first used by the writer about 3 years ago in repairing a defect in the lower left abdomen of a young woman after excision of a desmoid tumor. Removal of the neoplasm necessitated the sacrifice of the entire lower portion of the internal oblique with a portion of the transversus abdominus muscle together with the entire transversalis fascia in the groin as well as the external border of the rectus sheath. It was immediately apparent that approximation of the residual tissues to close the defect was impossible. The peritoneum bulged into the wound and the only remaining tissue which could be utilized for closure was the external oblique aponeurosis. The defect appeared too large to be securely closed by weaving over it free strips of fascia lata. It was at this juncture that the plan of employing the iliotibial tract as a pedicled graft on the tensor fascia lata muscle suggested itself as a feasible procedure.

[1]Presented before the Western Surgical Association at its meeting in Cincinnati, Ohio, on December 9, 1933.

SUMMARY OF CASES IN WHICH THE FLAP OPERATION HAS BEEN DONE

The operation has been performed fourteen times to date; twice for the repair of large defects necessitated by the removal of malignant tumors of the abdominal wall; four times in the mending of large vertical incisional hernias; once in the repair of a prominent bulge in a McBurney incision; once in the closure of a large recurrent femoral hernia, and six times in securing an adequate support in the repair of large inguinal hernias. Of these 6 inguinal hernias all were recurrent direct hernias with one exception. This patient had a swelling in the scrotum which measured 15 by 18 centimeters. At operation great difficulty was had in returning the many coils of small intestine contained in the sac to the peritoneal cavity, and all efforts proved futile until the fibers of the internal oblique were cut across. After the sac was evacuated of the herniated intestinal coils, the spermatic cord was found to be so elongated that the testis could be brought 3 inches below the patella.

The first patient with a hernia operated upon by this method had in effect both a femoral and a direct inguinal hernia, the inguinal ligament having been lost in three previous attempts by experienced surgeons at repairing the hernia. He still has a large direct hernia on the left side which also has been operated upon three times previously. Its repair by this method will be undertaken as soon as it is convenient for him to have it done.

One patient, an obese woman of 33 years, who had been completely invalided and bedridden because of a large incisional hernia, succumbed from diffuse minute cerebral hæmorrhages and fat embolism after the repair of the defect by this method. Over a period of 7 months, attempts at improving her strength by getting her up gradually resulted in her being able to stand and take a few steps with assistance. The risk of the operative procedure was well appreciated. A very satisfactory closure was obtained by the use of the iliotibial tract as a flap. About 24 hours after operation, hyperthermia developed (temperature 107 degrees F.) which proved refractory to treatment and exitus occurred 48 hours after operation. Minute cerebral hæmorrhages were demonstrated at postmortem examination. Death was believed to have been due to fat embolism. The employment of the fascial flap probably played no important rôle in her death.

In this group of difficult hernias there has been no recurrence, save that in Case 13. In this patient, who had two large incisional hernias which were repaired simultaneously, there appears to be a very small defect in the lesser hernia which the fascial flap did not cover. The particulars of each case are related in the summaries of the case histories.

Fig. 1. A photograph of position of the patient on the operating table. The tilt of the thigh permits of access to the strong iliotibial tract, the borders of which are outlined. Crosses are placed over the anterior superior spine, the greater trochanter and the biceps femoris tendon.

TECHNIQUE OF THE OPERATION

Careful pre-operative preparation of the skin is an important item of the operation. The routine method of skin preparation for all elective surgery at the University Hospital is as follows: A careful washing of the skin with tincture of green soap and water employing gauze sponges is done, after the hair is shaved off. The proposed operative fields are then sponged successively with benzine and ether. Finally a few gauze squares saturated with alcohol are fastened over the prepared areas beneath a sterile towel, which is held in place beyond the field of preparation by pieces of adhesive tape. When this dressing is later removed in the operating room, the skin is once again gone over with benzine and ether before the conventional tincture of iodine is applied in two coats. These in turn are removed when dry by the application of a saturated alcoholic solution of sodium thiosulphate (Richardson's solution) which decolorizes the iodine.

In the placing of the patient on the operating table, it is important to tilt up the pelvis and thigh of the side to be operated upon, by placing beneath them a few padded sand bags (Fig. 1). This maneuver permits of better access to the posterior and stronger portion of the fascia lata, viz., the iliotibial tract, which is to be mobilized as a flap. Spinal anæsthesia or ethylene and ether have been most frequently employed.

In patients with large incisional hernias, in whom the closure of the defect will necessitate considerable reduction in the size of the abdominal cavity, I have made it a practice to insert a Levine tube with multiple perforations through

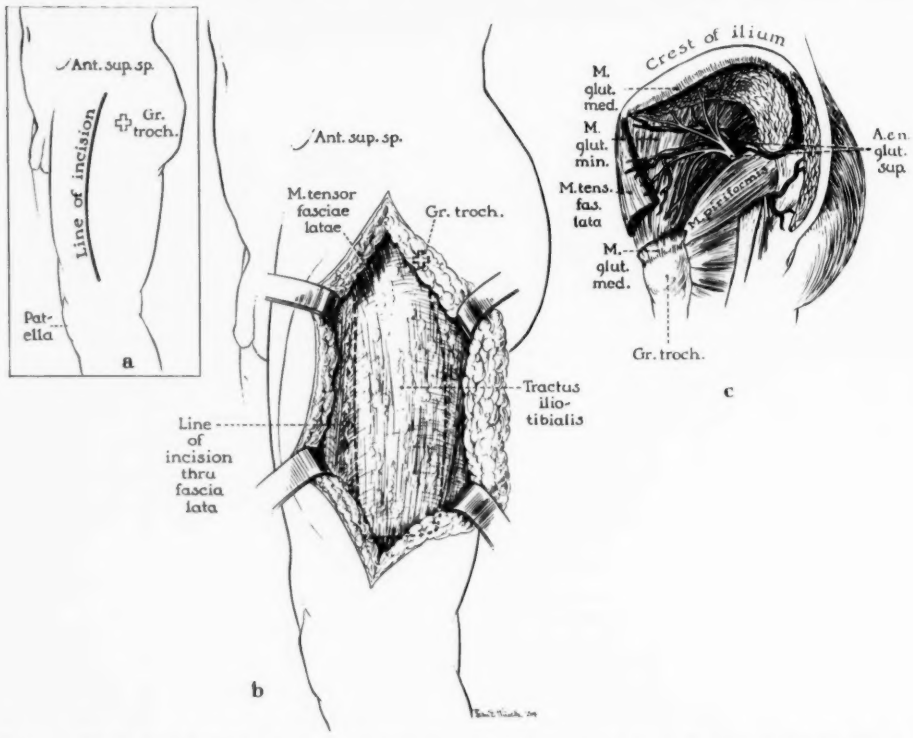

Fig. 2. a, The incision in the thigh. b, The incision in the fascia lata after undercutting the skin. c, A sketch illustrating the innervation and blood supply of the tensor fascia lata muscle from the superior gluteal nerve and artery. They come from beneath and course over the gluteus minimus muscle beneath the gluteus medius.

the nose into the stomach on the evening anterior to operation. The distal end of the catheter makes its way meanwhile into the duodenum and by the exertion of continuous suction on the duodenal tube with a water siphon after operation, distention can be prophylactically avoided.

I have elsewhere previously described in brief form some of the details of the operative procedure (33). A vertical incision is made over the anterolateral aspect of the thigh of the same side as the defect. The ends of this incision are tapered laterally to permit of wider undercutting of the posterior skin margin. The incision is begun about 3 inches below the anterior superior spine and may be extended downward to the knee (Fig. 2, a). In the repair of inguinofemoral defects, the lower margin of the incision need not go past the mid portion of the thigh. When the fascial flap is to be employed as a patch over the closure of a long incisional hernia, a generous incision in the thigh is necessary. The variable lengths of femurs are also to be borne in mind. Disparities in height of people are more due to differences in lengths of the lower extremity than to dissimilarities in trunk measurements. In short individuals, therefore, a relatively longer incision in the thigh may be necessary.

The incision in the fascia is made just lateral to the sartorius and is prolonged downward over the vastus lateralis. In the lower angle of the wound, the incision in the fascia is extended in a posterior direction for about 4 inches. A vertical extension of this incision is then made upward from its most posterior margin. In this manner the iliotibial tract of fascia is mobilized as a flap. When it is cut loose from the intermuscular septum between the biceps femoris and the vastus lateralis muscles, it remains suspended by the tensor fascia lata muscle only. The inferior surface of this flap is smooth; the superior surface is covered by a variable amount of fat. The superior gluteal nerve and artery reach the tensor

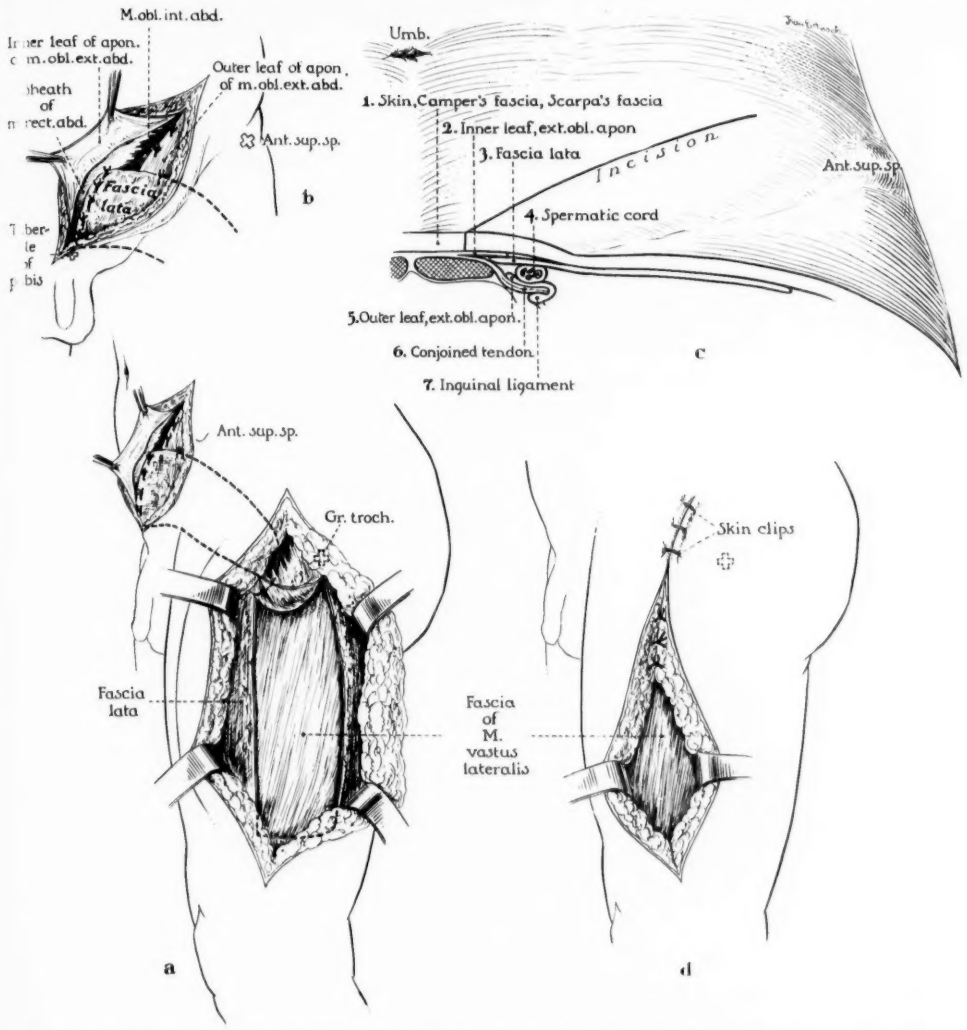

Fig. 3. a, A sketch showing the iliotibial tract of fascia swung into the groin by tunneling over Poupart's ligament in the repair of a recurrent inguinal hernia. b, The conjoined tendon has been sutured to Poupart's ligament and the outer leaf of the aponeurosis of the external oblique has been tacked down upon the fibers of the internal oblique and the conjoined tendon. The fascial flap is sutured to the external border of the rectus sheath and overlies the spermatic cord. The inner leaf of the external oblique aponeurosis is in turn sutured down upon the fascial flap. c, The structural relations obtained in the repair are shown in this sketch. d, The closure of the thigh wound. No attempt is made to cover the fascial defect incident to the removal of the fascial flap. Because of the covering of the vastus lateralis muscle by the fascia there is no tendency to muscle hernia.

fascia lata muscle from behind, and there is practically no danger of injuring them in raising the flap (Fig. 2, c).

In the repair of defects of the abdominal wall occasioned by the excision of neoplasms, it is best to pull the flap up beneath Poupart's ligament with the fatty side down. The fascia is then sutured to the edges of the remaining tissues, with interrupted sutures of chromic catgut (single No. 1). In event that fixation of this flap

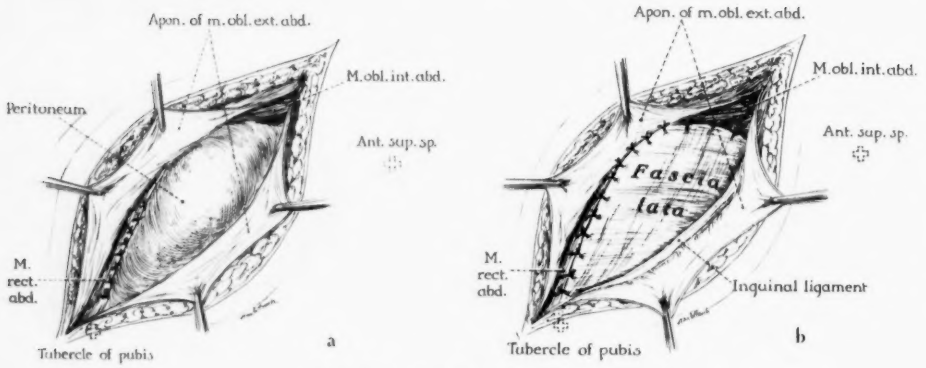

Fig. 4. (Legend on opposite page.)

with strips of fascia is to be preferred, such strips are readily available in the fascial edges of the thigh wound. No fascial structure of the body has greater tensile strength than the iliotibial tract. When incorporated in its closure with the adjacent edges of the tissues surrounding the defect, it may adequately replace these. Kirschner found that, whereas strips of periosteum were torn by a pull of 13 pounds, a similar sheet of fascia lata supported a weight of 90 pounds.

In the repair of hernias, however, in which one wishes to take advantage of the local tissues, even though they be rather weak, the mobilized fascial flap is best swung over Poupart's ligament, so that the local tissues may be better incorporated in the closure. In incisional hernias, I have found it to be better to suture the iliotibial tract of fascia over the site of suture as a patch. It may then be securely anchored to the external oblique aponeurosis or the anterior rectus sheath on either side. On occasions I have saved the long flap of adventitious fibrous tissue afforded by the expansion of the abdominal wall by the protrusion of the intraperitoneal contents. After approximation of the separated edges of the sheaths of the rectus muscles, however, I have usually deemed it better to cut away the carefully preserved adventitious peritoneal and fibrous tissue flap to permit of suturing the strong iliotibial tract over the normal fascial structures on either side. In unusually large hernias where an attempt at bringing the adjacent edges of the rectus sheaths together may prove disastrous to the patient because of the sudden diminution in size of the peritoneal cavity, it may be wiser to employ this thin flap to close the peritoneum. Then the sheet of fascia may be securely fastened to the adjacent fascial tissues.

In inguinal and femoral hernias, and in the former particularly, the mobilized iliotibial tract of fascia may be intimately incorporated with the adjacent tissues in the closure. Undoubtedly such a repair presents distinct advantages over mere employment of the graft as a fascial patch.

In the conduct of the operative procedure, the tumor or hernia is dealt with in the ordinary manner until the flap is to be swung into the wound. At this juncture the incision is made in the thigh. In hernias above Poupart's ligament the flap is rotated so that the upper fatty surface will remain up, the flap being brought into the wound by tunneling beneath the skin, Camper's and Scarpa's fascias but over the inguinal ligament. In the repair of operative defects of the abdominal wound as previously stated, the flap is not rotated and is brought up beneath Poupart's ligament. In the repair of femoral hernia, I have split the prepared tract of iliotibial fascia and have brought the lower half of it beneath Poupart's ligament and over the femoral vessels, anchoring it to the iliopectineal line and the pectineus fascia and Gimbernat's ligament. The other half is brought up over Poupart's ligament and sutured over the conjoined tendon to the external rectus sheath, after the conjoined tendon, pectineus fascia, and the lower portion of the flap are approximated. In inguinal hernias, after the sac is dealt with, the arched fibers of the internal oblique muscle and the conjoined tendon are first sutured to Poupart's ligament by four or five interrupted mattress sutures of chromic catgut (double No. 1) passed from and tied on the outer aspect of the inguinal ligament. The outer leaf of the external oblique aponeurosis is then sutured over the conjoined tendon and internal oblique muscle by a few interrupted

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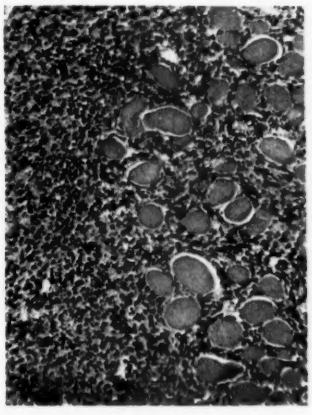

e.

Fig. 4. a, The defect created in the abdominal wall by the excision of a desmoid tumor (Case 1). The fibers of the internal oblique muscle and the transversalis fascia have been excised, a portion of the rectus sheath has also been excised, and the anterior and posterior borders have been reapproximated. b, The iliotibial tract of fascia from the thigh pedicled on the tensor fascia femoris muscle has been swung up beneath Poupart's ligament to close the defect. c, A recent photograph made after excision of the desmoid tumor and repair of the defect. The abdominal wall is strong and there is no suggestion of hernia even when the patient strains. d, Photograph of tumor. The excised portion of the rectus sheath may be seen at the left of the picture. e, Low power photomicrograph of the tumor, showing infiltration between the muscle bundles of the tumor. ×160.

sutures. The fascial flap from the thigh is now swung over the spermatic cord and anchored to the external border of the rectus sheath and the inner leaf of the external oblique aponeurosis is sutured over the fascial flap. In the event that the upper surface of the fascial flap is unusually fatty, a strip of fat is pushed aside where the fascial flap is to be sutured to the inner leaf of the external oblique aponeurosis.

In operations done for recurrent direct inguinal hernia under spinal anæsthesia, the nature of the support lent to the weak tissues by this method of repair may be readily demonstrated by having the patient cough or strain before and after transfer of the fascial flap.

Meticulous care is observed to obtain absolute hæmostasis in both wounds, and the subcutaneous tissues are approximated by several interrupted sutures of fine plain catgut which also catch the fascial flap, such that dead spaces are effectually obliterated. The skin is approximated by metal clips which are left for 4 or 5 days, when alternate ones are removed, and the remainder on the day following. A small rubber tissue drain is placed subcutaneously and left for 24 or 48 hours after the repair of a large incisional hernia. Inguinofemoral hernias have not been drained. No attempt is made to close the fascial defect in the thigh resulting from excision of the flap. It should be stated here, that, after excision of a fascial flap of about 4 inches in width, the gap is considerably widened by the retraction of the fascia. The vastus lateralis muscle remains covered by its fascia after mobilization of the iliotibial tract and muscle hernia does not occur. A small stab wound is made beneath both angles of the thigh incision to permit of the introduction of a small rubber tissue drain at the lowest point. After 48 hours these drains are removed. A fairly snug circular bandage is applied over the gauze dressing of the thigh wound. In bed, one or two pillows are placed below the knee to keep the thigh flexed.

These wounds usually heal kindly. The patient is kept in bed for 14 days or more, during which time he moves freely from side to side. A slight fullness persists beneath the anterior superior spine where the flap is swung upward. No functional disability in the thigh or leg is complained of because of transfer of the iliotibial tract. The only complaint which a few patients have made, is that of temporary paræsthesia at the upper end of the thigh wound, probably caused by the division of the lateral femoral cutaneous nerve.

INDICATIONS FOR THE OPERATION

It is difficult to appraise accurately the indications for the performance of this operation. It is

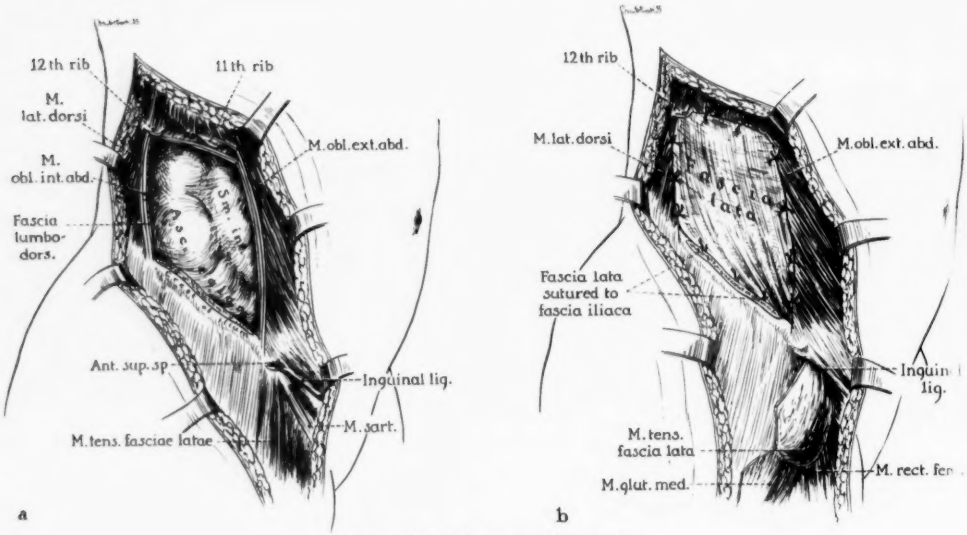

Fig. 5. (Legend on opposite page.)

no easy matter to say exactly in which instances a sheet of fascia lata employed as a free patch, after the method of Kirschner, would be the method of choice, or when free strips of fascia employed as an interweaving suture, as advised by Gallie and LeMesurier is to be preferred. It is to be admitted that both these methods permit of more universal application in the correction of tissue defects than does the writer's pedicled graft. In the repair of recurrent abdominal hernias and other large defects of the abdominal wall, however, there is available in the use of this method an effectual means of affording adequate and lasting support. The employment of a pedicled graft with its blood and nerve supply preserved intact, together with ease of transfer and absence of compromise of any function performed by the tendinous structure in the thigh has much to commend it. Even though the survival of free strips and sheets of fascia has been adequately demonstrated, certainly no one will contend that the transplantation of such potentially dead tissue is superior to the employment of a living graft. In difficult hernias, which test the worth of any method of repair, the iliotibial tract of fascia pedicled on the tensor fascia lata muscle as its base will give a support equal in strength and probably superior in healing qualities to that afforded by any other available method.

The employment of a pedicled sheet of fascia or muscle is also a well established principle in hernia repair. Halsted incised the anterior rectus sheat and turned it down over the conjoined tendon an approximated it to Poupart's ligament to afford more adequate support for the weakened tissues. DeGaray, in 1896, first employed the sartoriu muscle in the plugging of a large femoral hernia orifices. Since, the use of this muscle has bee practiced for similar purposes by a number o surgeons (19, 31). Bloodgood advised its use fo the reconstruction of Poupart's ligament. The adductor longus and pectineus muscles have bee similarly employed to plug the femoral ring. In the preparation of this paper, I have tried to as certain whether any method similar to that here described has previously been published. In 1910, Ach related the use of a pedicled flap of fascia lata 10 to 12 centimeters in length taken from just beneath Poupart's ligament to close the femora ring. Pólya in 1913 reported the employment o a compound pedicled flap of skin, fascia, and sartorius muscle in the repair of a large inguina hernia, cut from about the same location as Ach's fascial flap. In 1924, Mackenzie, of New Zealand described under the title of "The Repair of Large Abdominal Herniæ by Muscle Transplantation" the use of the tensor fascia femoris muscle itself for the repair of a large defect in the lower abdomen. These methods, and particularly the latter though similar in principle to that described here present significant differences obvious in the accompanying illustrations or on perusal of the text of this paper.

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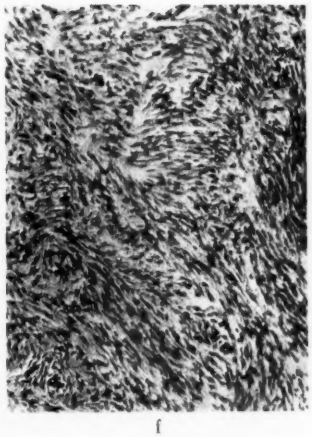

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Fig. 5. a, The defect in the abdominal wall in a young girl of 15 years (Case 2) after excision of a recurrent spindle cell sarcoma. A portion of the ilium has also been chiselled away to permit removal of a portion of the fascia covering the iliacus muscle to which the tumor was attached. b, Closure of this defect by the employment of a pedicled flap of the iliotibial tract. c, Photograph of the patient before operation. d, Photograph of the patient 17 days after operation. e. Photograph of the tumor. f, Low power microphotograph of the tumor, a spindle cell sarcoma. ×160.

I have once employed the fascia covering the gluteus medius muscle for the closure of a defect occasioned by the removal of a sarcoma of the innominate bone involving some of the abdominal muscles in a location similar to that shown in Figure 5. The gluteus medius fascia, however, is fairly intimately fused with the gluteus medius muscle, and its transference results in noticeable disability of the hip joint.

The only other autoplastic substances suggested for the closure of such hernia defects which have proved of some value, but have been used less frequently since the employment of fascia came into vogue, are the use of free grafts of periosteum or bone itself.

Among heteroplastic substances, a large number of different materials may be enumerated such as filigree wire, celluloid, lead and rubber plates, none of which enjoy usage today. The use of ox fascia, as suggested by Koontz (17), appears to have met with successes in the hands of several surgeons.

The earlier work of Nageotte and his colleague, Sencert, as well as that of Koontz, Rosenblatt, and Meyers and Wolfsohn would appear to have established the practicability of employing such heteroplastic fascial grafts. Koontz reports the use of this material in 85 hernias with only three recurrences. G. W. Horsley reports, however, that whereas he found that alcohol preserved ox

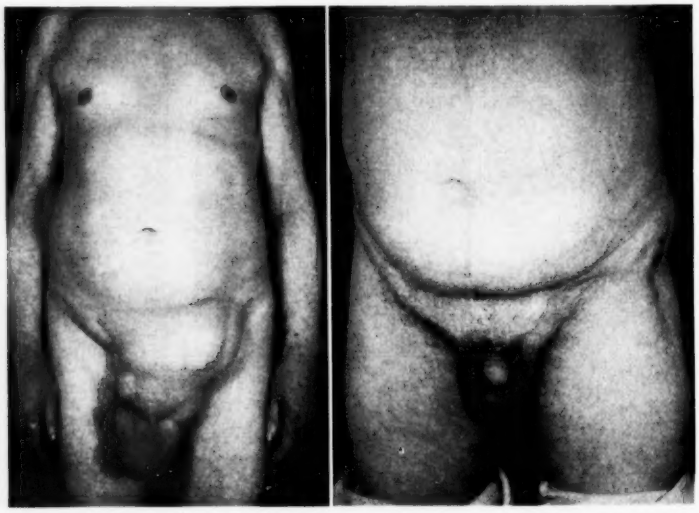

Fig. 6. a, left. This patient (Case 7) had a large recurrent direct and indirect hernia on the left side. b, A recent photograph made sometime after repair of the hernia and transference of the fascial flap.

fascia behaved in a manner similar to autogenous fascial grafts when incorporated in closures of the abdominal wall in dogs, in man the ox fascia broke down and was digested. The consensus of opinion of those who have worked with heterofascial grafts is that they are replaced by tissue which invades the graft from the host. It is also to be remembered that catgut is essentially a heteroplastic graft, and its temporary survival is a matter of common knowledge. It should perhaps also be stated that there are those who contend that this is likewise the fate of free autoplastic fascial grafts (25). The futility of the employment of homotransplants of skin and internal organs is now fairly well known (26). Relatively inert substances like bone and fascia, however, probably survive long enough to be adequately replaced by the tissues of the host.

Case 1. Mrs. B. C., Hospital No. 57610, aged 32 years. The patient comes because of a tumor in the left lower quadrant of the abdomen which she has noted for the past few weeks. The mass is not tender. She states that 6 years ago an abortion occurred after 5 years of married life. Since then she has suffered considerable pain and distress, especially at the time of the menses. Three years ago the patient was operated upon because of pain in the lower abdomen at the time of the menses. A small cyst in one of the ovaries was found. Appendectomy was done at the same time. A year ago the patient had a normal pregnancy with difficult labor; instrumental delivery. The child died the day after delivery. There is a midline suprapubic scar. In the left lower quadrant of the abdomen there is a hard tumor mass attached to the abdominal wall, apparently free from the ilium. The mass appeare to be about 7 by 5 centimeters in diameter. Pre-operativ diagnosis was probable desmoid of the abdominal wal When the blow test is done, by having the patient clos her glottis, hold her nose, and try to exhale forcibly, th tumor stands out prominently, indicating that it is prob ably within the abdominal parietes.

Operation was done February 9, 1931, under spina anæsthesia. An inguinal incision was made, and the tumo mass was found to lie just beneath the external oblique aponeurosis involving the internal oblique muscle and th transversalis fascia, as well as the lateral border of th rectus sheath. The tumor was widely excised, the trans versalis muscle in this region, together with the interna oblique muscle overlying it, being removed. A portion o the sheath of the rectus was also removed; it was recon structed by suturing the two edges of the rectus sheath together again. After removal of the tumor, it was ap parent that no local sliding of tissues would permit o bringing the wound edges together. Incision was then made in the thigh and a large fascial flap of the iliotibial tract of fascia lata was turned up. This was led under Poupart's ligament and sutured to the external border o the rectus sheath. This afforded a good covering, so that when the patient coughed there was no bulge of the peritoneum as there had been previously. No attempt was made to close the defect in the fascia of the thigh. The external oblique aponeurosis was sutured together over the fascial flap and both wounds were closed.

The operative convalescence was smooth and the patient left the hospital 18 days after operation. X-ray treatment having been given in the meantime to obviate as far a possible recurrence of the tumor. Recent examination shows the abdominal wound in good condition (Fig. 4,c) There is no evidence of return of the tumor and there is no hernia.

Case 2. Miss R. R., Hospital No. 621512, aged 15 years In June, 1933, the patient had an excision of a tumor on

Fig. 7. A, left. A woman with a recurrent femoral hernia with a large defect (Case 9). B, A recent photograph made sometime after the repair of the hernia by the transference of the iliotibial tract on the tensor fascia femoris muscle.

the lateral aspect of the abdominal wall which was then about the size of a lemon. The diagnosis was spindle cell sarcoma. About 2 months after excision, the growth recurred and she was sent here for further therapy. The patient complains of a constant aching in the mass which lies just above the right iliac crest and is about 2 inches in diameter. The skin appears to move over it fairly freely though the scar is somewhat broad over it. X-ray examination of the chest is negative for metastases.

On October 25, 1933, under nitrous oxide anæsthesia the growth was excised. A long circular excision was made excising the vertical portion of the old scar. The tumor mass was found to involve the latissimus dorsi and its fascia, together with the external oblique aponeurosis, a good portion of the internal oblique and transversalis fascia. In other words, the tumor involved the entire abdominal wall at its lateral aspect. The fascia covering the medial aspect of the ilium seemed to be attached to the tumor. Superiorly the fascial involvement appeared to go as high as the twelfth rib. After the skin was undercut anteriorly and posteriorly, the muscles of the abdominal wall were cut wide of the tumor. By means of a hammer and chisel about ¼ inch of the iliac crest was chiseled away, so that the fascia on the inferior aspect of the tumor was widely removed. After completion of this dissection there was a wide defect in the lateral abdominal wall. The abdominal viscera were covered only by the peritoneum, through which coils of small intestine and the ascending colon could be well visualized. When the patient strained, the intestines bulged into the wound. The greater portion of the twelfth rib was uncovered in the dissection above, the dissection being carried as high as the eleventh rib. It was apparent that no local sliding of tissue was adequate to close this wound. The lower part of the incision was then extended almost to the knee, and the iliotibial tract swung on the tensor fascia lata muscle or a base was used to close the defect. The superficial side of this fascial flap was brought in contact with the peritoneum, the flap being tunneled beneath Poupart's ligament below the anterior superior spine. This fascial flap was then sutured to the remaining fibers of the transversus abdominis and internal oblique muscle posteriorly and superiorly; anteriorly the fascial flap was sutured to the external oblique aponeurosis and inferiorly to the iliacus fascia just medial to the ilium. A very satisfactory closure was obtained by this means. Interrupted subcuticular stitches were placed in the subcutaneous tissues and several Michel clips were placed in the skin. A Penrose drain was left at the superior margin of the wound.

The patient convalesced uneventfully and was permitted to be up 14 days after operation, at which time the wound was well healed. Postoperative X-ray irradiation was also given (Fig. 5).

Case 3. Mr. F. Z., Hospital No. 68038, aged 57 years. An obese male presented himself with a huge hernial swelling in the right thigh and groin, the latter swelling extending into the scrotum. There was also a hernia on the left side for which the patient wore a truss, but it did not afford him as much trouble as the hernia on the right. The hernia on the right had been present for 23 years, during which time three operations for its repair have been done by competent surgeons; each time there has been prompt recurrence. The hernial mass could be reduced when the patient lay supine. There are scars in both inguinal regions.

Operation was done April 20, 1931, under spinal anæsthesia. The old scar in the groin was excised. There was a deficiency in Poupart's ligament extending from about its middle portion to the pubic tubercle. There was virtually therefore both a direct inguinal and a femoral hernia present. The spermatic cord was not visualized and the testis was not identified in the scrotum; it probably had been extirpated at a previous operation. After the external oblique aponeurosis was incised, opening was made directly into the hernial sac, which was found to contain a good deal of fatty omentum which was excised. The bladder formed the medial wall of the hernial sac. It was freed up and pushed back into the extraperitoneal space. The broad hernial sac was then sutured across, much in the manner as one closes a vertical abdominal incision. The conjoined tendon was quite deficient. What little remained of the conjoined tendon was approximated to Poupart's ligament by interrupted mattress sutures. The lateral leaf of the external oblique aponeurosis was then approximated over the conjoined tendon. A vertical incision was then made in the thigh and a very broad flap of the iliotibial tract of

Fig. 8. A photograph made after the repair of an unusually large incisional hernia (Case 11). Unfortunately a photograph was not made anterior to operation.

fascia lata was turned up. This tract of fascia was split into two portions. At the inferior margin of the wound it was brought down to the adductor magnus muscle and to the iliopectineal line where it was tacked in place. The upper portion was sutured over the conjoined tendon to the external border of the rectus sheath. The flap covered pretty well the deficient area in the abdominal wall. The conjoined tendon too had been sutured to the iliopectineal line where Poupart's ligament was deficient. The medial leaf of the external oblique aponeurosis was then brought over the fascial flap. The subcuticular tissues were reapproximated by interrupted sutures of chromic catgut and linen sutures were placed in the skin. He convalesced uneventfully and was dismissed from the hospital on May 10. He has no complaints referable to the right side of his abdomen and has remained well. The discomfort afforded by the hernia in the left groin is increasing and he will probably have it operated upon when convenient.

Case 4. Mr. F. I., Hospital No. 55078, aged 62 years. The patient was admitted to the University Hospital in July, 1930, for treatment of an enlarged prostate. A two stage prostatectomy was done; first a cystostomy, on August 23, 1930, following which the patient returned to his home for a while and then came back for a prostatectomy, on October 22, 1930. In April, 1931, he returned for the repair of a large hernia which was present on the left side. The blood pressure is 180/110. He complained of some precordial distress and physical examination and an electrocardiographic record indicate the presence of some myocardial damage. Because of the disability afforded by the hernia, however, he was anxious to have it operated upon. There is a midline suprapubic incision; the swelling in the left scrotum is enormous and measures 15 by 18 centimeters in diameter. The testis can be felt at the bottom of this swelling. The left scrotum does not transilluminate. Because of the œdema of the extremities and the hypertension, the patient was put on medical management before operation, which was done April 22, 1931, under spinal anæsthesia. A very large stretched out hernial sac was found in the scrotum. The sac when opened was found to contain many coils of small intestine intimately adherent to one another. The mesentery of the small intestine was very much thickened and œdematous. An attempt at reduction of the hernial content back in to the abdomen proved futile until the fibers of the internal oblique were cut across for some distance. Anterior to this, it appeared to be a debatable issue as to whether it would not be wiser to excise some of the intestine than to try to return them to the abdomen. After reposition of the hernial content, the peritoneal sac was closed by a running suture of chromic catgut, much as one closes a vertical abdominal incision. The length of the spermatic cord was such that when entirely freed the testis hung about 3 inches below the level of the knee joint. Because of the extreme length of the spermatic cord, the testis was sacrificed. A very thin conjoined tendon was sutured to Poupart's ligament. The outer leaf of the external oblique aponeurosis was sutured down upon the conjoined tendon. A vertical incision was made in the thigh and a liberal flap of fascia lata was brought up by tunneling over Poupart's ligament and the flap was approximated to the external border of the rectus sheath under tension. The medial leaf of the external oblique aponeurosis was then sutured down upon the flap. The subcuticular sutures were placed in the subcutaneous tissue and Michel clips were placed in the skin. No attempt was made to bring the fascia together in the wound of the thigh. The subcuticular sutures approximated the subcutaneous tissue. Michel clips were placed in the skin. The patient's convalescence was smooth, and he was dismissed from the hospital on the twenty-fifth day after operation.

Case 5. Mr. A. G., Hospital No. 61295, aged 65 years. A hernia in the left groin had been present for 13 years. Nine years ago it was repaired, but there was a return of the hernia after 9 months. The hernia was always reducible until about 3 months ago, since which time it has constantly been present as a large mass in the groin. A truss was worn up to the time the hernia became incarcerated since which time wearing has been discontinued. Pre-operative diagnosis: recurrent indirect inguinal hernia extending into the scrotum.

Operation was done November 14, 1931, under spinal anæsthesia; 150 milligrams of novocain crystals were satisfactory, reinforced by ethylene toward the end of the operative procedure because the anæsthesia was wearing off. A large indirect inguinal hernia of the sliding variety, with the greater portion of the descending colon and sigmoid flexure was found in the scrotum. The hernial sac was dealt with in the usual fashion. High ligation of the sac was impossible because the posterior wall of the sac furnished the blood supply to the descending colon. A small hydrocele sac present over the testis was inverted in the manner of the bottle operation. Because of the presence of the sliding hernia and the weak condition of the tissues, particularly the internal oblique and the conjoined tendons, it was felt wise to do a flap operation. After the suture of the conjoined tendon and the arched fibers of the internal oblique to Poupart's ligament by mattress sutures, the outer leaf of the external oblique aponeurosis was sutured down upon it. Then a vertical incision was made in the thigh, and the iliotibial tract of fascia lata was swung up, over the spermatic cord and anchored under tension to the external border of the rectus sheath. The medial leaf of the external oblique aponeurosis was then sutured down upon the flap. The subcutaneous tissues were closed with interrupted sutures of plain catgut and linen was used for closure of the skin. The wound in the thigh was similarly closed. The patient was dismissed from the hospital on the third of December, 1931. The operative convalescence was smooth and without event.

Case 6. Mr. H. S., Hospital No. 61810, aged 55 years. The patient was admitted to the University Hospital on January 14, 1932 for the repair of a left recurrent inguin

hernia. (On December 16, 1931, a carcinoma of the lip was excised by a "U" incision. January 7, 1932, submental and submaxillary node dissection was done. He was dismissed from the hospital on January 10 and returned now for the repair of the hernia.) Eighteen years previously the patient was operated upon for the repair of an inguinal hernia on the left which promptly returned. He has continuously worn a truss since. The tissues are not in very good condition. There is considerable relaxation of the abdominal wall and marked protrusion is present.

Spinal anæsthesia, with 150 milligrams of novocain, was given and proved satisfactory. A fairly large indirect hernial sac as well as a large direct sac on the medial side of the deep epigastric vessels was found. The tissues of the inguinal canal were very weak and frayed out. When the patient coughed under anæsthesia there was marked relaxation of the entire abdominal wall in this area. The hernial sac was dealt with in the usual fashion. The arched fibers of the internal oblique and the conjoined tendon were approximated to Poupart's ligament by interrupted sutures of chromic catgut. The outer flap of the external oblique aponeurosis was sutured down upon the arched fibers of the internal oblique and the conjoined tendon. A vertical incision was made over the external aspect of the left thigh and the iliotibial tract of fascia lata was turned up as a flap with the tensor fascia femoris muscle as its base. The flap was tunneled over Poupart's ligament and sutured under tension to the external border of the rectus sheath over the spermatic cord. The medial flap of the external oblique aponeurosis was then sutured over the flap. The subcuticular tissues were sutured with plain catgut, and the skin with linen. The wound in the thigh was similarly dealt with. The patient was dismissed on January 29, 1932, after an uneventful convalescence.

Case 7. Mr. I. S., Hospital No. 62556, aged 55 years. Twelve years ago the patient fell from a ladder and injured his left groin. Six months later a definite hernia was noticeable there. Six years ago this was repaired, but returned some 3 or 4 months later since which time the patient has worn a truss and later an abdominal binder. There is a large recurrent indirect inguinal hernia on the left side going into the scrotum. There is also a direct inguinal hernia present as indicated in a rather large bulge of the anterior abdominal wall. There is also a small hydrocele over the left testis.

Operation was done February 5, 1932, under spinal anæsthesia, 150 milligrams novocain crystals being used. An unusually large hernial sac was present. The spermatic cord was apparently independent of the hernial sac and had no relation to it. The external oblique aponeurosis was quite redundant owing to the bulge of the abdominal wall. Omentum and small intestine were present in the hernial sac. The hernial sac was defined immediately beneath the external oblique aponeurosis as a thin membrane. The hernial sac was dealt with in the usual manner after its contents were returned to the peritoneal cavity. Because of the weakness of the tissues in the lower abdomen it was thought wise to swing the iliotibial tract of fascia lata up from the thigh, which was done after approximation of the conjoined tendon and the fibers of the internal oblique to Poupart's ligament. The hydrocele over the testis was also dealt with. The external leaf of the external oblique aponeurosis was sutured down upon the conjoined tendon and the flap from the thigh was swung over the spermatic cord and anchored to the external border of the rectus sheath. The medial flap of the external oblique aponeurosis was then sutured down upon the flap. Both wounds were closed.

The patient was dismissed from the hospital on February 22, 18 days after operation. He returned to the hospital March 10, with a small hæmatoma in the scrotum which necessitated incision and drainage. A recent examination shows him to have remained well (Fig. 6).

Case 8. Mr. W. S., Hospital No. 616055, aged 49 years. This patient had had a right inguinal hernia since childhood. About 4 years ago it began to increase in size and dipped into the scrotum. At this time the patient began to wear a truss. But because the truss held it unsatisfactorily he had the hernia repaired surgically elsewhere in May, 1932. Four months later he noticed that the hernia had recurred, and 6 months after operation the hernia was as large as ever. There is an enormous defect in the right lower abdominal wall with a marked bulge extending down into the scrotum. There is a scar from a previous operative procedure.

Operation was done April 10, 1933, under ethylene anæsthesia. The old scar was excised and the hernial contents were found immediately beneath the skin. The internal and the external ring were widely separated from one another. No tissue was found adherent to Poupart's ligament. There was a hernia of the bladder, a direct hernial sac and an indirect hernial sac present. The bladder bulged well into the abdominal wound. After the hernial sac was dealt with and after approximation of the conjoined tendon to Poupart's ligament, with interrupted sutures of chromic catgut, the iliotibial tract of fascia was swung up from the thigh. The external leaf of the external oblique aponeurosis was first sutured down upon the conjoined tendon. The fascial flap from the thigh was led over Poupart's ligament and over the spermatic cord and anchored to the external border of the rectus sheath. Finally, the medial leaf of the external oblique aponeurosis was sutured upon the flap.

The patient was dismissed from the hospital April 25, 1933, 15 days after the operative procedure, with the wound well healed. He has remained well.

Case 9. Mrs. T. B., Hospital No. 628981, aged 48 years. The patient was operated upon in this hospital 12 years ago for femoral hernia (right). This recurred 6 years later. She has worn a truss until about a year and a half ago, since which time the hernia has not been reducible. The patient is obese and presents in the right groin, lateral to the pubic tubercle below Poupart's ligament, a large bulging mass. The mass is easily reduced if the patient lies down. The femoral ring is unusually large.

Operation was done September 9, 1932, under spinal anæsthesia. An incision was made above Poupart's ligament but the sac could not be reduced. The peritoneum was therefore opened up in the inguinal canal and the hernial sac dealt with. The residual fat remaining incarcerated in the femoral canal was then extirpated. The iliotibial tract was turned up as a flap from the thigh and this was split in two. A portion of it was led above Poupart's ligament and a portion beneath Poupart's ligament. The portion led beneath Poupart's ligament was sutured to the iliopectineal line, to Cooper's fascia, and to the conjoined tendon; the conjoined tendon was then approximated to Poupart's ligament. The portion of the fascial flap led above Poupart's ligament was sutured to the external rectus sheath after tacking the external leaf of the external oblique aponeurosis in situ. The medial leaf of the external oblique aponeurosis was then sutured over the flap. Skin wounds in both thigh and groin were closed. Necrosis developed in the midportion of the thigh wound, but healed up under conservative management.

The patient was dismissed from the hospital on October 12. The hernia has remained well (Fig. 7).

Case 10. Mrs. A. N., Hospital No. 61247, aged 63 years. The patient comes for the repair of a large hernia in a McBurney incision after an appendectomy done 25 years ago. The blood pressure is 180/130. The heart is some-

what enlarged to the left. Urine examination shows a trace of albumin and an occasional white cell cast; phenolsulphonephthalein is 60 per cent. Electrocardiogram shows slight left ventricular preponderance. On November 13, 1931, under drop ether anæsthesia the hernia was repaired. There was a marked protrusion of the abdominal wall through the old McBurney incision. The old scar was excised and several coils of intestine were found adherent to the abdominal wall. The gut was freed from the anterior abdominal wall. The peritoneum and rectus sheath were imbricated in one layer. Because of the relative non-dependability of the tissues it was thought wise to swing the iliotibial tract of fascia up from the thigh, which was done in the usual manner. This fascial flap was sutured over the entire region of repair of the hernia. Interrupted sutures were placed in the subcutaneous tissues; linen was used in the skin. A very satisfactory repair was made.

The patient had some difficulty with the healing of the wound on the thigh. There was no evidence of infection. She was dismissed from the hospital on December 20, 1931, and has remained well.

Case 11. Mr. A. B., Hospital No. 63903, aged 33 years. Five years ago this patient was operated upon at another local hospital under the diagnosis of acute appendicitis through a low right rectus incision. The peritoneal cavity was opened and it was apparent that a perforation of a duodenal ulcer had occurred. The incision was then extended up to the ensiform process and the perforation was closed. The patient recovered from the operation but the wound became infected and the patient developed an enormous hernia through its entire extent, extending practically from the pubis to the ensiform. Through this incision the spleen could be palpated as well as the abdominal aorta through the greater portion of its course. He reports now for the repair of this enormous hernia because of its increase in size and because of constant pain on exertion.

Operation was done May 18, 1932, under spinal anæsthesia, reinforced by ethylene toward the completion of the operation. The greater portion of the old scar was excised, the skin edges undercut, and the peritoneum was immediately cut down upon. The rectus muscles were widely separated. The omentum was detached where it was adherent to the anterior parietal wall. The bleeding points were ligated. A few interrupted sutures were placed more effectively to coaptate the separated structures. No attempt was made, however, to bring the widely separated ends of the rectus muscles together. About ten or twelve interrupted sutures were placed approximating the peritoneum and the rectus fascia covering the rectus muscles in one layer. A long incision was then made in the thigh and a very long flap of the iliotibial tract was turned up which reached to the very top of the abdominal incision. This flap was sutured *in situ* and the wound was closed. He had a slight fever for the first few days after operation, the highest reading being on the third day after operation, viz., 101.2 degrees F. The patient was dismissed when the wound healed, on the twentieth day after operation, and the hernia has remained well.

Case 12. Miss G. C., Hospital No. 614175, aged 33 years. In 1925 this patient was operated upon elsewhere for the excision of her gall bladder and the appendix. After operation a large hernia developed in the operative incision. In January, 1932, an attempt was made to repair this large hernial defect by employment of a flap of fascia, from the left thigh. The patient had a stormy convalescence. Infection developed in the wound and the hernia continued to increase in size. During the past year she has had to remain almost constantly in bed because of her disability and weakness. Attempts had been made to have the patient get out of bed, but, because of weakness, she was unable to walk unassisted. She was also quite adipose, but reduced about 20 pounds on a low calorie diet. Neurological examination failed to show any evidence of any old anterior poliomyelitis, which might have been responsible for the weakness of the abdominal wall. The risk of operating upon this patient was fully appreciated. About 7 months elapsed from the time of first seeing the patient until I consented to operate upon her.

Operation was done under spinal anæsthesia on February 9, 1933. The old scar was excised through an elliptical incision. Intestines, colon, and stomach were entirely subcutaneous due to wide retraction of the rectus muscles. The greater portion of the great omentum was cut away, and the intestines were dropped back into the free peritoneal space. The rectus muscles were widely separated but of fair substance. A good portion of the liver protruded into the wound. There were no unusual intraperitoneal findings. About twenty interrupted sutures of chromic catgut were used to approximate the rectus muscles. Approximation was difficult. A number of interrupted sutures had to be reapplied to bring the structures in contact. A running suture of chromic 40 day catgut was put over this. The iliotibial tract was brought up from the thigh over Poupart's ligament to cover the approximated tissues. I felt on completion of the operation that a very satisfactory closure had been made. The incision in the right thigh extended practically to the knee. Both wounds were closed with Michel clips. Twenty-four hours after operation, her temperature went to 107.0 degrees F. The patient became stuporous and died 48 hours after operation. A nasal tube had been put down before operation to reduce the gaseous distention. Hæmorrhagic encephalitis was found and it was thought that fat embolism was the cause of death.

Case 13. Mrs. M. S., Hospital No. 615493, aged 44 years. The patient had had two previous operations elsewhere. In 1921, she had a cæsarean section through a left rectus incision. About 2 years ago she had the gall bladder removed through an incision made parallel to the costal margin. A hernia occurred in the gall-bladder incision and a year ago an operation was directed at its cure. It failed and there was prompt recurrence. The patient presents herself now with a tremendous hernia in the gall-bladder incision and also a large defect in the upper end of the left rectus incision. Because of the patient's general status and weakness it was believed wise not to undertake the repair of the hernia. It had been described as an inoperable hernia. The patient's incapacity is such, however, that she cannot work because of the hernia and she was anxious to have it repaired.

On March 29, 1933, under spinal anæsthesia, reinforced with ethylene gas toward the end of the operative procedure, a repair of these hernias was done. The main hernial sac in the old gall-bladder incision lay immediately beneath the skin. When it was uncovered it was found that the other defect was just 2 inches to the left of the most medial portion of the large defect. After the contents of the large hernial sac on the right had been replaced in the peritoneal cavity, it was thought wise to divide the tissue between these two hernial orifices and to deal with them as one hernia. A fairly satisfactory closure of the defect was obtained by a series of interrupted sutures. Because of the inherent weakness of the tissues it was felt best to make an incision in the thigh and bring up the iliotibial tract as a flap, which was done anterior to the Poupart's ligament, tunneling beneath the skin. The apex of the flap was brought to the upper part of the incision on the right, but it was not broad enough to cover the left

hernia. A few days after the operation, the patient developed a rather serious wound infection in the right thigh, and ran a high fever for a considerable period of time. It was thought that the contamination of the wound occurred through the use of a sand bag employed to tilt the thigh which had previously been used in a septic operation. (The custom had been to wash these sand bags off with antiseptic solution. Since this time, however, we have made it a routine practice to autoclave these sand bags, after they have been used.) The dressing had become soaked with blood during the operative procedure and the sand bag perhaps had contaminated the dressing. After a long period of time under Dakin's irrigation the wound cleared up.

This patient was dismissed from the hospital well and the wound healed by July 3, 1933. The large hernia in the gall-bladder incision apparently is cured; in the hernia to the left of the midline, in which fascia was not used because the flap was not broad enough there is a suggestion of a recurrence.

CASE 14. Mrs. M. C., Hospital No. 604082, aged 51 years. This patient comes because of a large incisional hernia on the right. She has had 16 pregnancies and has given birth to 7 children. The hernia followed an incision made 12 years ago when she was delivered by cæsarean section for eclampsia. About 25 years ago she had a previous operation through an incision at the same site for the removal of her appendix and right tube. The bulge in the incision occurred shortly after the cæsarean section was done and it slowly increased in size; in the last 5 years there has been a large protrusion. When the patient stands there is a teat-like process at the lower end of the incision through which the intestine protrudes. The separation in the wound runs the entire length of the wound from the pubis to just opposite the umbilicus. The separation is several inches in width. There is a small lipoma in the left labia. Otherwise the physical examination is negative.

Operation was done on November 27, 1933, under spinal anæsthesia which was reinforced toward the end of the operative procedure by the administration of ethylene. A vertical incision was made excising the old scar. The intestine was found to lie immediately beneath the skin. There was wide retraction of the rectus muscles. The small intestine was adherent to the sac in a couple places, and when the skin was detached from the gut, the gut was partially denuded at one place necessitating inversion by a pursestring suture. There were no unusual intra-abdominal findings. Many interrupted sutures of chromic catgut were placed approximating the rectus muscles. A small flap was left on the right, consisting of adventitious tissue which had constituted the peritoneal lining of the hernial sac. The right flap was pulled over the left. When these sutures were tied, however, a good portion of the right flap was cut away because it was not deemed to be of much value. What little remained was tacked down upon the external oblique aponeurosis on the left. The fat was widely undercut. Because of the weakness of the tissue and insecurity of the closure, it was felt wise to swing up the iliotibial tract of fascia from the right thigh. This fascial flap was then tunneled beneath the skin over Poupart's ligament and tacked over the site of previous hernioplasty. The incision in the thigh was shorter than it should have been, and because of the patient's short stature, it scarcely reached to the top of the incision. An extra strip of fascia lata was then cut and was imbricated superiorly over the site of closure. Subcutaneous sutures of catgut were employed to approximate the subcutaneous tissues and obliterate the dead space. Michel clips were placed in the skin. The lower wound was similarly closed after obtaining adequate hæmostasis. Small Penrose drains were left in both wounds. The patient convalesced uneventfully, save for somewhat prolonged drainage from the abdominal incision.

SUMMARY AND CONCLUSIONS

A method for the repair of difficult hernias and large defects of the abdominal wall is presented through the employment of the iliotibial tract of fascia as a flap, pedicled on the tensor fascia femoris muscle. This muscle may be swung upward with its nerve and blood supply preserved intact. The transference of this musculotendinous graft may be easily made and its loss to the thigh does not compromise any function which it ordinarily performs. In the repair of large defects of the abdominal wall in which the loss of tissue precludes approximation, this pedicled graft is best drawn beneath Poupart's ligament with the superficial or fatty side down and sutured into the defect. In the repair of hernias, it is best brought up over Poupart's ligament and incorporated in the closure, the flap being slightly rotated at its base, so that the superficial or fatty side remains up.

In difficult recurrent inguinal or femoral hernias, this flap of fascia may be intimately incorporated with the suture of the adjacent tissues. In the repair of incisional hernias, the flap is best sutured as a patch over the site of closure, it being anchored securely to the normal adjacent fascial structures.

In the use of this strong sheet of fascia pedicled on a muscle whose blood and nerve supply remains preserved, one has available a simple but effectual and practical method for the mending of difficult hernias and large abdominal defects, which meets all the requirements demanded for ideal tissue transference.

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DRAINAGE OF THE COMMON BILE DUCT FOR GALL STONES

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IN 1921 Reid and Halsted (3) reported a method of draining the common duct through the stump of the cystic duct following cholecystectomy, a procedure to which they gave the name cysticocholedochostomy. At that time it was pointed out that by this method the amount and duration of the external drainage of bile were considerably less than in those cases drained in other ways. This is due to several factors which may be enumerated. First, the opening made in the common duct can be closed completely and securely with two rows of sutures. The absence of a foreign body (the drainage tube) at this line of suture predisposes to more benign healing of the incision. It should heal *per primam* with very slight scarring of the duct. Second, the tube emerges from the duct through a long, narrow channel, so that it remains water tight and there should be no leakage of bile into the wound. Third, the removal of the tube does not disturb the incision in the common duct, and leaves a long, narrow tract which tends to heal very quickly.

The method can be carried out only after removal of the gall bladder and in instances in which the cystic duct is not occluded and can be dilated sufficiently to permit passage of the drainage tube through it. In those cases in which on account of debility or extreme jaundice it seems advisable to explore the common duct and relieve the obstruction to it first, the method may not be applicable. Reid and Halsted believed that in most cases it was desirable to remove the gall bladder, and in this clinic the routine has been to remove the gall bladder first, and then to explore the common duct as this is technically easier and, in practically all cases with stone in the common duct, the gall bladder is so diseased that it should be removed. It seems to us that the argument for leaving the gall bladder as a possible channel to carry the bile to the intestinal tract in case of injury or damage to the common bile duct is not valid, for in our experience in the cases in which it would be most needed, the gall bladder has been so modified by disease as to be valueless as a biliary channel.

While the method of draining the common duct through the stump of the cystic duct is undoubtedly widely used, it is not as universally popular as is the use of a T-tube to judge by the methods described in textbooks of surgery. Cysticocholedochostomy seems to offer definite advantages over other methods and should be more widely used. In this connection it should be emphasized that incision of the common duct through the stump of the cystic and insertion of the tube through this opening, followed by suture, does not have the advantage of allowing the tube to emerge away from the suture line as it does in the technique devised by Reid and Halsted.

Their method has been used for a number of years as the routine procedure for drainage of the common bile duct at the Cincinnati General Hospital, and we wish here to report the experience with it at this institution. The technique which is used is as follows: After removal of the gall bladder, an incision is made in the common bile duct about 1 centimeter below the entrance of the cystic duct, for exploration, or removal of stones. The edges of this incision are held open by traction sutures of fine silk. This is much better than the use of Allis clamps or forceps, as there is less trauma to the duct. After the stones are removed and it is demonstrated that the common duct is patent into the duodenum and into the hepatic ducts, a small catheter is inserted through the stump of the cystic duct into the common duct (Fig. 1). The size of this catheter depends on the diameter of the cystic duct, usually a No. 12, 14, or 16 French being used. It should fit snugly in the cystic duct. Several holes are cut in its sides near the tip, but the rounded tip itself is not cut off. This catheter is directed downward in the common duct toward the ampulla, and its position can be directed through the incision in the common duct. With a very small cystic duct it may be easier to pass the tube into it through the opening in the common duct. A small probe can be passed first, a stout thread tied to it and pulled through, and the catheter pulled through by means of the thread. After the tube is properly placed, it is fixed in position by a suture of fine plain catgut, it being tied tightly to the stump of the cystic duct. The incision in the common duct is then closed with a continuous suture of fine plain catgut. This may be inverted and reinforced with a row of interrupted fine silk sutures (Fig. 2). Several cigarette drains are placed near, but not against, the line of suture,

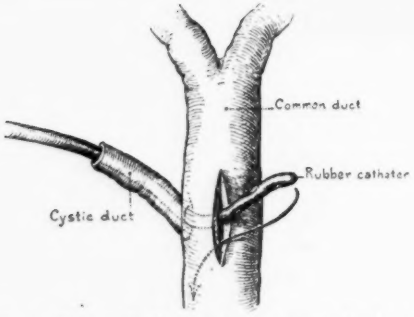


Fig. 1. The small side openings are made in the catheter after it has been introduced through the cystic duct and pulled out of the opening in the common duct. It is then returned to the common duct and anchored to the cystic duct before the incision of the common duct is closed. In this way one assures the final position of the end of the catheter.

and the abdomen is closed. The catheter is fastened to the dressings and its free end is placed in a bottle strapped to the patient's side.

The amount and character of the biliary drainage is charted twice daily by the nurse. When the drainage becomes scant in amount, either the bottle is elevated so as to increase the pressure in the catheter, or the tube is clamped off for a period of hours. If the closure around the tube is tight and the incision in the common duct has healed there will be no drainage of bile around the tube. If the common duct is still partially obstructed by œdema or for other reasons, pain will occur when the tube is clamped or elevated. On the other hand, with the tube clamped or elevated, and no pain, and no drainage of bile through or around the tube, we can be sure the bile is entering the duodenum. We regard elevation of the tube as better than clamping to cause increase of the pressure in it and in the bile ducts. A technique for this procedure was described by Reid (2) in 1923. After drainage from the tube ceases, the tube may be removed, and it is almost certain that there will be little or no drainage of bile from the wound, and that it will soon heal.

In this clinic the common bile duct is not opened and explored routinely in all cases in which the gall bladder is removed, but it is always examined by palpation although it is appreciated that, as Lahey and others have pointed out, a stone may be overlooked in this way. The common duct is explored when a stone is felt in it, when there has been jaundice present before operation, or a history suggestive of stone in the common duct. It is also explored if it is dilated or its wall thickened. In some instances in which the caliber of the cystic duct is large, it has been possible to pass a probe through the stump into the common duct and on into the duodenum without incision of the common duct itself, though this is not recommended as it may lead to undue trauma and inaccurate information. Following such a procedure, drainage is usually instituted for fear œdema may occlude the common duct following the manipulation.

In some cases drainage of the common duct through the stump of the cystic duct is not possible due to the complete obliteration or the small caliber of the cystic duct. It is necessary in many cases to dilate the cystic duct with a clamp or a special dilator before even the smallest catheter can be inserted. When this is not possible we advise the use of a catheter directed downward in the common duct which is inserted through a small stab wound in the duct separate from the exploratory incision, and then complete closure of the latter incision (Fig. 3).

During the past 9 years at the Cincinnati General Hospital, there have been 42 cases in which the records were complete, and in which the common duct was drained through the stump of the cystic duct. The common duct was incised for exploration in 24 cases, and in the 18 remaining cases the common duct was probed for obstruction through the stump of the cystic duct. The opening in the common duct was closed tightly with catgut in 1 case, with silk in 10 cases, and with catgut and silk in 13 cases. The differences in technique are undoubtedly due to the fact that a number of different surgeons operated upon the patients. Of the 42 cases, 38 are available for study, the 4 remaining patients having died.

The total number of days in hospital after operation for the 38 cases was 1074, an average of 28 days per case. The longest hospital stay after operation was 118 days, and the shortest 14 days. In the first of these cases a persistent biliary fistula has developed, most likely due to failure to remove all of the stones in the common duct, but since the patient is fairly comfortable, and his age and general condition are such that further operation would be decidedly dangerous, he has not been operated upon again. This is the only case of persistent biliary fistula in this series.[1] It was found that there was considerable variation in the length of time that the tube was allowed to remain in the duct. The tube was removed on

[1] Because of progressive jaundice another operation was performed a year later. A large, solitary stone was removed from the common duct. The stump of the cystic duct was isolated, and a catheter inserted through it into the common duct. This tube was removed on the seventh day; drainage of bile ceased on the tenth day. The patient has been quite well ever since.

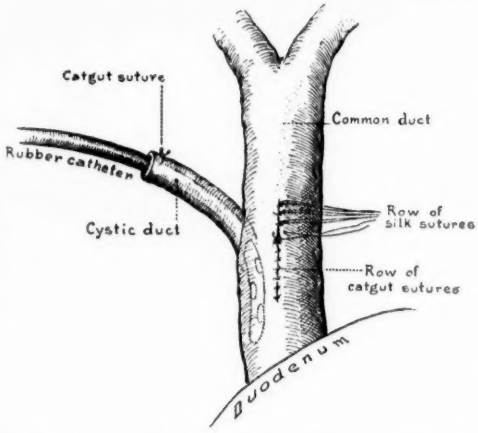


Fig. 2. Cysticocholedochostomy completed except for the second row of sutures in the common duct.

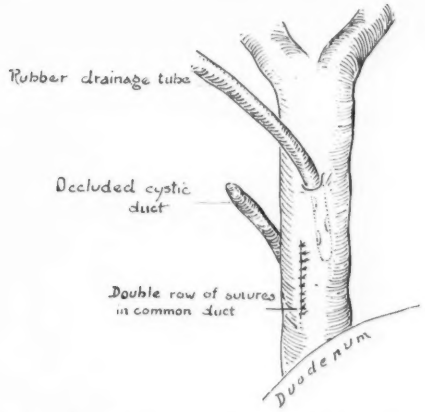
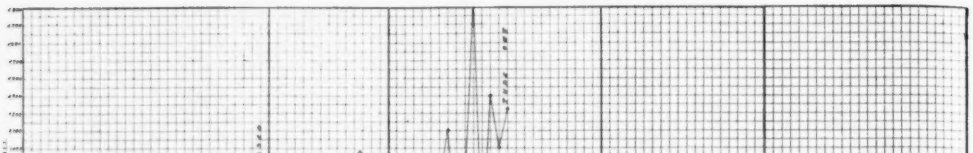


Fig. 3. A method of avoiding the placing of a tube through the incision of the common duct when a cysticocholedochostomy cannot be done.

the eleventh day in the greatest number of cases, and ordinarily drainage from the wound ceased within 4 days. The longest time that a tube was allowed to remain in place was 27 days, and the shortest was 7 days. In the first of these the drainage had ceased by the twenty-third day, and as there was no reason in the record why the tube was allowed to remain in place, one can only speculate as to the real reason. It is possible that the drainage was allowed to continue because of the pancreatitis that was found at the time of operation. It has been suggested by numerous authors, and in some clinics it is a routine procedure, to drain the common duct over a long period of time in cases of pancreatitis. In this clinic such a procedure is not routine, and the time for the removal of the tube depends usually on the reaction of the patient with reference to the decreasing icterus, and the decrease in the amount of external biliary flow. The experience with this case indicates that prolonged drainage of the common bile duct can be carried out by this method if it is desired. The drainage of bile in this case which varied from 60 to 650 cubic centimeters per day may be seen in Chart I. The drainage through the tube ceased on the twenty-third day, the tube was removed on the twenty-seventh day, and the patient was discharged 30 days after operation, with the wound almost completely healed. In the other case the drainage tube was removed on the seventh day and all drainage of bile had ceased by the twelfth day. The amount of bile drainage which varied from 180 to 380 cubic centimeters per day, may be seen on Chart II. The patient was discharged on the fifteenth day in excellent general condition with the wound completely healed.

In this series of cases there was also found to be marked variation in the quantity of bile which drained through the tube. In one case a total of 11,030 cubic centimeters of bile was collected in the 14 days the tube was in place, the largest amount in any 24 hour period being 1800 cubic centimeters on the tenth day (Chart III). In contrast to this, in another case the total drainage in 14 days was 1580 cubic centimeters, the maximum amount in one day being 280 cubic centimeters (Chart IV).

The average daily drainage of bile is shown in Chart V. The amount of drainage in every case was not noted on the record for every day. To obtain the averages shown in this chart, only the quantities of bile that were recorded were taken into account including, of course, those cases in which no drainage was reported. At the bottom of the chart can be noted the number of cases which entered into each day's calculation. It is realized that this method of arriving at an average is inaccurate, but the figures are probably the best that could be reached from the available data. This chart shows that the smallest average amount of bile (110 cubic centimeters) drained on the day of operation, and the largest amount (450 cubic centimeters) on the seventh day. There was a rapid rise in amount from the first to the second day, then a slower increase to a peak on the seventh day. From the seventh to the tenth day, there was a slow drop, followed by a considerable drop on the eleventh day, which was the average time at which the tube was



Charts showing the amount of bile collected through the drainage tube on successive days: I, The drainage of bile in the case in which the tube remained in place for the greatest number of days. II, The drainage of bile in the case in which the tube remained in place the shortest time. III, Chart of the patient who showed the greatest total drainage of bile through the tube. IV, Chart showing the smallest amount of drainage of bile of any patient in this series. V, Chart showing the average amount of drainage of the bile for all the cases. The number of patients entering into each day's calculation is shown in the lower line of figures.

removed. Drainage of bile from the wound after removal of the tube ceased in 2 to 4 days as a rule, though here again the exact time was not given definitely on the records in a sufficient number of the cases to allow exact computation. For example, the record might show that bile was draining the day after removal of the tube. The next note several days later might state that bile drainage had ceased, but not the day on which it had ceased. It was unusual for bile to continue to drain more than 7 days after removal of the tube.

A careful study of the records with regard to the temperature curves reveals that the highest pre-operative temperature was 103.8 degrees occurring on the day of operation. The maximum postoperative temperature was 103.6 degrees and occurred on the sixth day. The removal of the tube did not affect the temperature curve in any manner nor did it affect the general condition of the patient.

In the series of 42 cases, 4 died, a mortality rate of 9.3 per cent. Autopsies were obtained on 3 of them. One of these died of pneumonia on the sixth day, another of acute hæmorrhagic pancreatitis, also on the sixth day. In the 2 remaining cases there was extensive infection with abscess formation present. In both cases the gall bladder was removed in spite of the presence of the marked infection. As the records of these 2 cases are reviewed, one questions whether the patients might not have survived if a less radical surgical procedure had been carried out at the time of this operation, perhaps drainage of the common bile duct alone, or better, of the gall bladder, if that would have sufficed to drain the common duct.

A study of 12 patients who were operated upon during the same period of time as the above series, in which it was impossible to drain the common duct through the stump of the cystic duct, revealed the following facts: (1) The most common cause for inability to drain through the cystic duct was the small caliber of the duct. (2) The drainage of bile through the wound was longer following removal of the catheter. The average was 18 days, the shortest 4 days, and the longest 90 days. (3) There was considerable drainage of bile around the drainage tube onto the dressings. (4) The hospitalization period was longer due to the protracted biliary drainage and the subsequent failure of the sinus tract to granulate and heal. (5) The mortality rate was higher (25 per cent) although this may be partially discounted because the series is smaller and the cases in general were poorer operative risks with more marked pathological change.

DEDUCTIONS

The method of drainage of the common bile duct through the stump of the cystic duct has proved highly satisfactory, and is in our opinion the method of choice where drainage of the duct is indicated. It was rather a surprise to find that in this small series such a relatively large proportion of the cases had had the common duct explored through the cystic stump. We do not recommend this procedure as it may lead to undue trauma to the duct, and to inadequate exploration. In addition, there is really no contraindication to incision of the common duct when exploration is necessary, for when drainage is done by this method the incision can be closed

completely and accurately by suture, and usually heals *per primam.*

The only serious drawback to the routine use of cysticocholedochostomy is the necessity of removing the gall bladder at the same operation. This we believe is an advantage provided the patient is able to stand the entire operation, as the convalescence is shortened and no secondary operation is necessary. The procedure should not be done on patients whose general condition is so poor that only the least amount of operative work is warranted. In such cases, drainage of the gall bladder or common duct, often without removing any stones, should be done with the idea of carrying out a completed operation later when the patient's general condition has improved. Several of the deaths in this group were probably due to too extensive procedures at one stage. If the gall bladder is not removed, we believe that drainage of the common duct should be instituted through a small catheter directed downward in the common duct, and inserted into it, if possible, through a separate stab wound so as to allow complete and accurate closure of the incision through which exploration has been done. In none of our cases was a T-tube used for drainage and we see no justification for the use of this type of tube, for it seems obvious that the wound produced by the removal of it is as large or nearly as large as the original incision. We also see no advantage in incising the cystic stump and continuing the incision into the common duct, and then allowing the drainage tube to emerge through the cystic duct. While this gives a long narrow channel for the drainage tube and allows removal of the tube to be easily accomplished, it does not keep the tube away from the line of suture which is one of the major objectives of the method of Reid and Halsted. Finally, there seems to be no justification for closing the common duct tight with no drainage after it has been explored. The method described is so simple, easy, and safe that one should not run the risk of a possible extravasation of bile into the peritoneal cavity in the absence of a drainage tube.

SUMMARY

Records of 42 cases of drainage of the common duct through the stump of the cystic duct were reviewed. Four of the patients died. In the 38 remaining cases, the total number of postoperative hospital days was 1074, an average of 28 days per case. The longest postoperative stay was 118 days; shortest, 14 days. The longest time the tube was kept in the duct was 27 days, the shortest 7 days, the average 11 days. Drainage of bile from the wound usually ceased within 2 to 4 days after removal of the tube and rarely continued for more than 7 days after the tube was removed. The total and the daily drainage of bile varied considerably in different individuals. In general, it was least on the day of operation, increased to a maximum on the seventh day, and then decreased slowly until the eleventh day, after which time it ceased rather abruptly.

Records of 12 cases of drainage of the common duct through the exploratory incision were also reviewed. Three of these patients died. In the 9 remaining cases the total number of postoperative hospital days was 378, an average of 42 days per case. The longest time the tube was kept in the duct was 14 days, shortest 9 days, average 11 days. In almost every case there was leakage of bile around the tube before it was removed. Drainage of bile from the wound after removal of the tube usually continued for 10 days to 2 weeks, and in 1 case it continued for 90 days.

CONCLUSIONS

Drainage of the common duct through the stump of the cystic duct should be the method of choice when drainage of the duct is necessary. It allows complete and accurate suture of the exploratory incision which predisposes to early, firm healing of this incision with minimal scarring. It provides a long narrow channel for the drainage tube, which ordinarily remains water-tight until it is time to remove the tube. Removal of the tube causes very little damage or disturbance to the common duct, and drainage of bile from the wound after removal of the tube is of very short duration. The method therefore reduces the total loss of bile and shortens materially the duration of the convalescence.

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PARTIAL GASTRIC FUNDUSECTOMY IN TREATMENT OF PEPTIC ULCER

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A REVIEW of editorials in recent literature (1) emphasizes the conflict of opinion regarding the etiology and the treatment of peptic ulcer.

Partial fundusectomy (aiming at a diminution of the acid secreting surface, rather than the removal of the alkaline secreting, "ulcer bearing area") was presented (2) as a compromise between gastro-enterostomy and subtotal gastrectomy; the former considered by some as not radical enough; and the latter, by many, as too radical.

Partial fundusectomy permits a retention of the important antro-pyloro-duodeno mechanism.

The indications for such procedure are: peptic ulcer of the duodenum; peptic ulcer of the stomach (because of potential malignant change, to be supplemented by local resection); peptic ulcer of the jejunum, after gastro-enterostomy. Organic pyloric obstruction calls for additional operation.

The technique is simple:

After the abdomen is explored and proper indications for the procedure are established, the stomach is delivered and the general peritoneal cavity is walled off.

The omentum is separated, with careful hæmostasis, from the middle third (the usual site and extent of the partial fundusectomy) of the greater curvature.

A double wedge-shaped section of both the anterior and posterior fundal walls with a common base at the middle third of the greater curvature is removed, the two incisions meeting about 1 inch below the lesser curvature on both anterior and posterior walls. After proper pre-operative management, the stomach should be empty and as hyperchlorhydria is usual, the contents are comparatively sterile. Non-use of clamps will permit accurate hæmostasis and careful examination of the interior of the stomach.

A holding forceps is applied at the apex of the triangle in the posterior gastric wall, and another forceps is used to approximate the divided greater curvature. Traction on these forceps brings the posterior wall into apposition suitable for hæmostasis and suturing.

The posterior wall from the upper, lesser curvature, to the lower, greater curvature, is repaired with through-and-through (mucosa to mucosa) catgut stitches. The reconstruction of the stomach is completed by closure of the anterior wall from the lower, greater curvature to the upper, lesser curvature, by continuing the suturing with over and over (seroserous) stitches (Fig. 1).

The attaching of the greater omentum to the minimized greater curvature completes the operation and the abdomen is closed without drainage.

The management after operation will be the same as is customary after any other type of stomach operation.

Clinical results, to date, following this operative procedure are reported in Table I. All except the first case are too recent for consideration of the remote result, but in Case 1, which was considered intractable, a follow up after 2 years shows a satisfactory, i.e., symptom free, result: a fact which would suggest a definite field of usefulness for par-

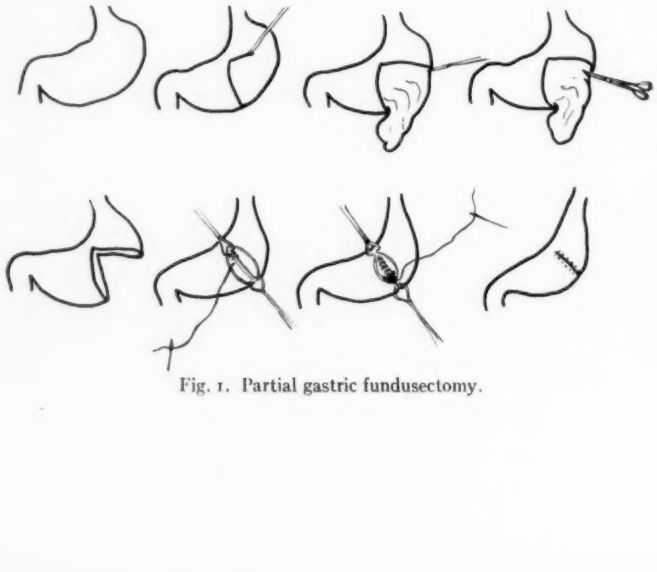

Fig. 1. Partial gastric fundusectomy.

TABLE I.—CLINICAL RESULTS

No. Name Age Sex	Family history	Previous history	Chief complaint	Physical examination and laboratory findings	X-ray and diagnosis	Date operative findings	Result
1 H. P. 24 M	Father: Gastric ulcer Mother: Gall stones Brother: (1) Gastric ulcer perforated (1) Gastric ulcer medical treatment Sister: Gastric ulcer, two operations, symptoms persist Referred by Dr. T. D. Smith, Neenah, Wis.	Rheumatism Tonsillitis Endocarditis 1921 Appendectomy 1928 Duodenal ulcer perforated, gastro-enterostomy 1930 Degastro-enterostomy	Typical symptoms of peptic ulcer	Nodular goiter Endocarditis Gastric acid high	Deformed duodenal cap Pylorus patent Duodenal ulcer recurrent	12–14–31 Duodenal ulcer no obstruction	6–19–34 Symptom free
2 S. S. 48 M	Negative Referred by Dr. J. F. Schneider, Oshkosh, Wis.	1920 Appendectomy 1925 Gastro-enterostomy for duodenal ulcer 1932 Hæmorrhoidectomy	Sour stomach Food ease Melæna	Heart murmur, endocarditis Gastric acid high	Duodenal cap not visualized Pylorus patent Filling defect at stoma Jejunal ulcer after gastro-enterostomy	21–13–33 Jejunal ulcer at gastro-enterostomy stoma	Death the 14th day postoperative. Pulmonary embolism
3 A. D. 40 M	Father: Gastric ulcer Referred by Dr. V. Marshall, Appleton, Wis.	1920 Appendectomy and gastro-enterostomy for duodenal ulcer 1928 Hæmatemesis and melæna 1931 Transfusion 1933 Chronic bleeding with symptoms of jejunal ulcer	Symptoms of jejunal ulcer with melæna and anæmia	Negative Gastric acid high	Filling defect at stoma Jejunal ulcer after gastro-enterostomy	2–15–33 Jejunal ulcer at gastro-enterostomy stoma	Feb. 1934 Symptom free
4 F. B. M	Negative Referred by Dr. C. J. Combs, Oshkosh, Wis.	1925 Appendectomy, Cholecystectomy non-calculous 1926 Return of symptoms 1933 Constant distress, "burning"	"Acid stomach" "burning" No food ease	Negative Gastric acid high	Deformed duodenal cap Pylorus patent Duodenal ulcer	6–19–33 No ulcer demonstrated, "gastritis"	Mar. 1934 "Burning" in stomach
5 J. C. 57 M	Negative Referred by Dr. H. Meusel, Oshkosh, Wis.	Previous attack 20 yrs. ago	Pain, nausea, gas, food ease. Onset at 57 sudden	Negative Gastric acid high	Deformed duodenal cap Pylorus patent Duodenal ulcer	8–15–33 Duodenal ulcer, no obstruction	Apr. 1934 Symptom free
6 M. C. 55 F	Negative Referred by H. F. Woolfenden, Royal Infirmary, Liverpool, England		2 years' duration Pain, nausea, vomiting, loss of weight	Negative ooo	Penetrating ulcer lesser curvature Pylorus patent Gastric ulcer	11–25–32 Fundusectomy with excision of ulcer	11–24–33 Symptom free
7 P. T. 41 M	2 sisters "Ulcer of stomach"	1917 Appendectomy 1926 Symptoms of peptic ulcer at intervals 1933 acute hæmatemesis	Gas pain, qualitative food distress Food and soda ease Seasonal variation	Blood pressure low Gastric acid high	Deformed duodenal cap No pyloric obstruction Duodenal ulcer	5–28–34 Duodenal ulcer	6–22–34 Symptom free

tial fundusectomy in suitable cases of peptic ulcer.

The postoperative history in Case 1 follows:

March 15, 1932, he had gained 3 pounds in weight and was symptom free, and has remained so to date. Test meal shows free hydrochloric acid absent, total acid 37.

June 25, 1932, free hydrochloric 18, total acid 52.

August 30, 1932, free acid 33, total acid 40. Barium meal showed duodenal cap irregular, with no 6 hour retention. There is present a very slight irregularity at the greater curvature.

May 1, 1932, by letter, symptom free.

October 9, 1933, by letter, at work symptom free.

November 24, 1933, by phone, at work, unable to come for test meal and barium check up.

The only medical treatment or "management" has been frequent small feedings of general diet, with omission of salt.

In addition to the 6 clinical cases mentioned, the following personal communications bearing upon the experimental aspect of this subject are appended.

Professor A. C. Ivy of Northwestern University Medical School on November 29, 1933, writes:

"In studying the effects of total fundusectomy on the occurrence of jejunal ulcer, we followed this plan: Approximately 75 per cent of the fundus was removed by a "wedge" operation; then 1 month later a Mann-Williamson operation was performed. We then followed the dogs closely for the clinical evidence of the development of ulcer and checked by autopsy, gastric analyses being made from time to time. We have operated upon 20 dogs. The results indicate that fundusectomy delays the development of jejunal

ulcer in these dogs. The acidity of the gastric contents is decreased at first, but later returns to normal in those dogs that develop hypertrophy of the stomach. When we compared the results obtained from the 12 dogs—experiment complete—with a "time of ulcer occurrence curve" constructed from results on 40 control dogs, we observed a prophylactic delay value of about 60 per cent. If we could satisfactorily control the nutritional factor in these dogs, we believe that the results would be better, except in those dogs that continue to bolt their food and show much hypertrophy of the gastric remnant."

Professor Frank C. Mann, of the Mayo Foundation at Rochester, Minnesota, on December 5, 1933, writes:

"In regard to our work on partial gastric fundusectomy, I wish to state that the work was done by Dr. Watson, who followed out the acidity and pH of the gastric contents before and after removal of various portions of the fundus. In his immediate results his work corroborated your experiments, namely, that there was a decrease in acidity roughly paralleling the amount of the fundic mucosa removed; however, the acidity returned to normal within a few months' time after operation in almost all of the animals studied. We have not been able to determine one phase of the subject in which I am interested, namely, the effect of partial gastric fundusectomy upon the total amount of gastric juices secreted. I am inclined to believe that if there were any permanent clinical results it would be more on the basis of actual reduction of the amount of gastric juice and therefore acid produced, than any change in regard to the degree of acidity."

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SUBPHRENIC ABSCESS IN CHILDREN[1]

JAY IRELAND, M.D., CHICAGO

JUDGING from the reports in the literature subphrenic abscess in children is quite rare. Because of this it was thought that a report in detail of 6 cases occurring in childhood would be of unusual interest. This disease entity was first described by Barlow in 1845.

Of Gatewood's 41 patients all were adults except one who was a child aged 8 years. However, Brown reported 4 cases under 10 years of age and one of these was only 22 months of age. The ages of the cases here reported range from 14 months to 12 years. Two were males and 4 were females.

Most subphrenic abscesses follow an infection elsewhere in the body. Elkin stated that in approximately 0.6 per cent of all cases of suppurative appendicitis, an abscess develops beneath the diaphragm. Of Ochsner's 84 cases 35.2 per cent and of Gatewood's 41 cases 26.3 per cent followed appendicitis. Their series were composed chiefly of adults, while in this series, made up entirely of children, 4 (66⅔ per cent) followed acute appendicitis. Of Gatewood's cases 34.1 per cent followed stomach or duodenal lesions while only 1 (16⅔ per cent) followed a ruptured gastric ulcer in the present series.

Two of Ochsner's and Graves' 5 cases and 1 (16⅔ per cent) in the present series followed pneumonia but none of Gatewood's cases followed this disease. Cases of subphrenic abscess have been reported following perforations of the stomach, duodenum, appendix, gall bladder; also following primary diseases of the liver, bile passages, lung, œsophagus, kidney, pancreas, spleen, spine, rib, diverticula; following pelvic infections, and pelvic fractures. They have also followed pyæmia and distant infections. Aynesworth's case followed a liver abscess in which drainage was instituted and numerous cases have followed rupture of a liver abscess (Roesner, Rácz, Harrington, Schwarts). Kuru reported a case following splenectomy.

Schwarts stated that the most common types of organisms present are streptococci, staphylococci, colon bacillus, and not infrequently, amœba. Scott reported 1 case due to gonococci and said he was unable to find any other similar case in the literature. Graves and Ochsner reported 2 cases due to actinomycosis and found a total of only 8 other cases reported in the literature.

Cultures of the pus obtained from the subphrenic abscess at the time of operation in Case 1 of this series showed Bacillus coli; Case 2, Staphylococcus aureus and Streptococcus mitior; Case 3, Bacillus coli; Case 4, Streptococcus hæmolyticus; Case 5, Bacillus coli and anaerobic coccus; and Case 6, non-hæmolytic streptococcus. Culture of the pus obtained from the abdomen at necropsy in Case 2 showed Bacillus coli, Streptococcus viridans, and an organism resembling Klebs Loeffler bacillus. The last named organism was considered to be a contamination. From this summary it is noted that there is no uniformity of organisms present.

The different locations of the abscesses have been stressed by many observers and need not be repeated here. In the present series 4 were on the right side and 2 on the left. The abscess was located between the liver and the diaphragm in the 4 cases in which the abscess was on the right side. All were thought to be intraperitoneal.

Ochsner believed that less than one-half of subphrenic infections lead to suppuration. Even when fluid is present, in some instances it may be serous and not progress to pus formation. As to the manner of formation, some of the abscesses are thought to be primary; others occur by direct extension or by the hæmatogenous or lymphatic routes. A rest abscess was mentioned by Ochsner as one following a general peritonitis in which all the pus is removed except that which remains in the subphrenic space.

Gas is often present in these abscesses and may be from a perforation or, according to some observers, from gas producing organisms. Beye pointed out clearly that a serous pleural effusion often occurs early in subphrenic abscess and may proceed to an empyema. He also stated that the supraphrenic reaction frequently subsides spontaneously after subdiaphragmatic drainage. Thoracic complications occurred in 23, or 75 per cent, of his 31 cases of intraperitoneal subphrenic infections, while on the other hand, in 337 cases of empyema only 1 traversed the diaphragm to produce a subphrenic abscess and that one was due to injury of the diaphragm during drainage of an empyema. His findings would also indicate that a subphrenic infection produced by the streptococcus in combination with Bacillus coli or Bacillus proteus is especially likely to traverse the diaphragm. Thoracic complications were present in 3, or 50 per cent, of the cases in the present series.

[1]From the Surgical Service of Dr. A. H. Montgomery at the Children's Memorial and the Presbyterian Hospitals. Presented before the Chicago Surgical Society, February 2, 1934.

The symptoms often appear to be a continuation or exaggeration of the primary disease. Brown stated that in his cases that followed operations, the earliest time from the primary operation till the drainage of the abscess was 3 weeks and the longest was 11 months. In the present series of 6 cases there were 3 in which an operation preceded the abscess formation. The time between the operation and the formation of the abscess was 23, 36, and 256 days, respectively, with an average of 105 days.

One-half of Gatewood's cases had hiccough. This was not present in any of the series reported here. Cough, dyspnœa, and pain and tenderness in the subphrenic region are usually present. Œdema of the lower axilla was present in 4 of Schwarts' 8 cases.

The physical signs usually described include dullness to flatness, diminished breath and voice sounds, and vocal fremitus, with the presence of râles over the base of the lung. The dull area is convex upward and does not change its location with a change in position of the patient. If gas is present in the abscess cavity, three zones of different resonance on percussion are present; normal above, tympany caused by the gas below this, and below the tympany is an area of flatness or dullness which on the left side is caused by pus and on the right side is caused by pus and the liver. If fluid is present in the pleura a fourth zone, one of flatness, is present which is between the pulmonary resonance above and the tympanitic zone caused by the gas beneath the diaphragm. This fourth zone was mentioned as being present in 1 of the 4 cases in this report in which the abscess was on the right side. Signs of shifting of fluid were found in Cases 2 and 3.

Tuft stated that the heart may be pushed upward but judging from the literature, this is rarely the case and it was not pushed upward in any cases of this report. He also reported that the heart is seldom pushed laterally. It was pushed laterally in 2 cases of this series. Elkin pointed out that there may be bulging in the epigastrium if the pus travels along the falciform ligament. This sign was present in 2 cases and bulging of the intercostal spaces in 1 case of this series. In 2 cases prominent veins were present over the abdomen.

The temperature in all cases was of the remittent type, as it was in the cases reported by Janz. At its highest point it averaged 104.3 degrees F. rectally. The leucocyte count ranged from 11,150 to 28,100 with a preponderance of the polymorphonuclear forms. The pulse rate varied proportionately with the temperature change.

The roentgenographic evidence is important but is often very difficult to interpret. Hoover stated that with a subdiaphragmatic abscess the costal border had a greater lateral excursion on the affected than on the sound side. The diaphragm is smoothly elevated on the affected side according to Gatewood. Hodges pointed out that the diaphragm is usually less elevated in the intraperitoneal cases. According to LeWald, in certain persons the left side of the diaphragm may be as high as the right, or in cases of eventration the left side of the diaphragm may reach even a higher point than the right side. Some believe that elevation of the posterior part of the diaphragm in lateral roentgenograms is of much importance. The diaphragm was elevated in all the cases reported herein.

Stress has been placed on the immobility of the diaphragm in subphrenic abscess. Hodges stated that a distant infection such as appendicitis may often cause an immobile diaphragm similar to that seen in a subphrenic abscess. In 2 cases of this series a decreased mobility of the diaphragm was noted on the affected side. Gas below the diaphragm was demonstrated roentgenographically in 3 cases.

There are few diseases which cause more uncertainty in the diagnosis. Brown was able to make a correct pre-operative diagnosis in only 7 of his 18 cases. In all the cases of this series a definite diagnosis of subphrenic abscess was made before operation. If the presence of a subphrenic abscess is kept in mind especially in patients with an infection such as appendicitis which does not clear up in the usual time, the diagnosis will be made more readily.

Gas just beneath the diaphragm is of some importance. However, Podkaminsky reported a confusing case in which the colon was between the liver and the diaphragm giving the appearance of free gas under the diaphragm. Therefore, although the presence of gas between the liver and diaphragm is not absolutely pathognomonic it is very suggestive.

A roentgenogram taken in a lateral position will often demonstrate whether the fluid is above or below the diaphragm as shown in Case 3. A roentgenogram taken in the Trendelenburg position may show the lower limit of the cavity, since the gas may be movable and in this position pass to the caudal limit of the cavity. LeWald advocated the injection of air into the abdominal cavity as a diagnostic procedure but it is questionable whether this would be entirely safe in all patients. Stewart suggested that as an aid in left sided inflammations, air be injected into the

stomach or a barium meal given. A stomach tube was passed in Case 5 and it demonstrated clearly that the gas, which was present in the abdomen, was not in the stomach. In Case 6, a sinus remained following operation which did not heal, so opaque material was injected into it to determine whether the sinus led into the subphrenic space, but the procedure was unsuccessful.

At the time of operation, even after all the available diagnostic means have been employed the pus is often difficult to find. Many needle punctures may be necessary to locate the pus.

In the diagnosis other inflammatory diseases of the upper abdomen and the lower chest must be excluded. Touroff mentioned the diagnostic difficulties encountered in an encapsulated collection of pus between the lower surface of the lung and the diaphragm. Rácz stated that liver abscesses have ruptured through the diaphragm causing a hepatobronchial fistula without formation of a subphrenic abscess. In Case 6, the diagnosis was still uncertain even after operation. There was definite pus above the diaphragm but there was some question in the minds of some of those who examined the patient as to whether there was pus beneath the diaphragm. Beye mentioned that sometimes the opening through the diaphragm has been found only by palpation through an empyema drainage opening. Viethen thought it quite important to differentiate an abscess of the retroperitoneal space since the operative procedures in the treatment of the two affections may be quite different. He pointed out that in retroperitoneal space infections there are fewer lung symptoms, the diaphragm is not pushed up, it moves on the affected side, and there is no pleural involvement. Yater and Otell successfully employed thorium dioxide sol intravenously with hepatosplenography in excluding 2 cases of suspected subphrenic abscess. Klein pointed out the uncertainty in differentiating an osteomyelitis of the spine.

The death rate in subphrenic abscess is higher than it should be. Brown's mortality in 18 cases which were operated on was 44.4 per cent; Gatewood's, in 38 cases (all adults except 1), was 29 per cent; Hodges', in 9 cases, was 40 per cent; and Ochsner's and Graves' was 33.6 per cent in 1743 cases collected from the literature and including 50 of their own. Of the 6 cases here reported, 1 (16⅔ per cent) died.

Beye found that in 23 cases with thoracic complications his mortality was 43.5 per cent, but in 8 cases without thoracic complications it was 25 per cent. Elkin stated that practically all patients who are not operated on die.

One of Schwarts' patients died 20 months after having had pneumonia and subphrenic abscess. In Case 6 almost 1 year passed from the time of the primary infection until the subphrenic abscess was diagnosed and operated on.

The treatment, of course, is surgical. Drainage may be made through the anterior or posterior approach. If the posterior approach through the pleura is attempted and the costal and diaphragmatic pleural layers are not adherent, the primary operation should be a subperiosteal removal of a section of one or more ribs and packing of this wound for a few days to obtain adhesions between the two pleural layers. A few days later by a secondary operation an attempt is made to locate and drain the abscess cavity. In case the two layers of the pleura are already adherent, the operation may be completed in one sitting. In some cases it may be impossible to decide before operation whether the two pleural layers are adherent, in which case, the two stage operation must be used if the transpleural route is chosen. Brown thought it best to drain below the diaphragm (i.e. subpleurally) if the infection is retroperitoneal as in a perinephritic abscess. Ochsner and Nather were firm believers in the posterior retroperitoneal approach for those in the right superior posterior space. In 19 cases so treated their mortality was 5.2 per cent. The abscess may cause a definite pointed bulging which is visible externally. In that case, it is best to drain at the place where bulging occurs, whether this be anteriorly or posteriorly. The drainage tube should be left in place longer than in abscesses elsewhere because a subphrenic abscess has a tendency to recur. In Cases 3 and 4 the tubes were left in 39 and 14 days, respectively, and the abscesses recurred. It was concluded that the tubes were removed too soon.

In this series 3 cases were drained through the anterior abdominal wall and 3 posteriorly by the transpleural route.

CASE 1. J. P., female, aged 12 years, was admitted to the Children's Memorial Hospital December 28, 1932, presenting a history of vomiting, fever, and pain in the right lower quadrant of the abdomen persisting for a period of 3 days.

Examination showed the throat was red but there was no upper respiratory infection. There was tenderness and rigidity of the muscles of the right lower quadrant of the abdomen and a probable intraperitoneal mass on the right side. Her temperature was 102 degrees F. rectally, pulse 100, and respiration 24. The blood examination showed 5,050,000 erythrocytes, hæmoglobin 86 per cent, and 26,000 leucocytes with 86 per cent polymorphonuclear forms. The urine examination showed nothing abnormal; the vaginal smear was negative for gonococci; and her blood Wassermann was negative.

On the day of admission a diagnosis of acute appendicitis was made and the patient was operated on under ethylene anæsthesia. Pus was encountered at the operation and the appendix was not removed, but a drain was inserted into the peritoneal cavity. Cultures of the pus showed Bacillus coli.

Following the operation the patient continued to be quite ill and after 6 days a fæcal discharge appeared through the operative wound. On January 5 (8 days after admission), there was suppression of breath sounds and râles over the base of the right lung. In the abdomen a tender mass was present which extended from the right costal margin downward the breadth of two fingers. Six days later a roentgenogram showed increased shadows in the right hilum, thickening of the right costal pleura, and elevation of the right half of the diaphragm, with compensatory lowering of the left half. On January 12, there was some bulging in the right upper anterior abdomen and in the region of the right eighth, ninth, and tenth ribs posteriorly. On January 18 a roentgenogram showed the heart farther to the left than normal.

Because of secondary anæmia on January 19 she was given 300 cubic centimeters of citrated blood intravenously.

A tentative diagnosis of subphrenic abscess was made and on January 21 (24 days after admission), under nitrous oxide anæsthesia, after a partial costectomy of the eleventh and twelfth ribs, a needle was inserted a distance of 3 inches through the diaphragm. One hundred and forty cubic centimeters of pus was obtained, having a fæcal odor, and which on subsequent culture revealed Bacillus coli. Because of the danger of infecting the pleural cavity, the needle was left *in situ* and connected with a bottle of water making a closed drainage. The wound was packed with iodoform gauze and left undisturbed for 4 days. The wound was then reopened under nitrous oxide anæsthesia and a forceps was passed alongside the needle into the abscess cavity. About 250 cubic centimeters of pus was obtained and a large drainage tube was inserted. Nine days later the patient became afebrile but the wound continued to drain until April 15 (108 days after admission). On May 13 an appendectomy was performed and she was discharged as cured May 26.

Case 2. M. C., female, aged 2 years, was admitted April 13, 1933, with a history of pain in the abdomen of 4 days' duration, and convulsions, fever, and green stools for 3 days.

Her birth had been normal and the previous history was not noteworthy.

On admission there was a redness of the throat and a nasal discharge. The spleen was palpable. The lower abdomen was tender and the abdominal muscles were rigid throughout but more so on the right side. She had a fever of 101 degrees F. rectally and a pulse rate of 120. The blood examination showed 70 per cent hæmoglobin and 17,500 leucocytes with 85 per cent polymorphonuclear forms. The urine showed nothing abnormal; a vaginal smear was negative for gonococci; and the Mantoux test was negative.

A diagnosis was made of nasopharyngitis and peritonitis probably due to the pneumococcus organism.

On the day of her admission an epidemic of measles broke out in the hospital and as no convalescent measles serum could be obtained 20 cubic centimeters of convalescent erysipelas serum was given into the quadriceps muscle, as a general prophylactic measure.

Two days later the patient vomited and her abdomen became distended. Some prominent veins were noticed beneath the skin of the abdomen and they were more marked on the right side. The abdominal muscles were rigid throughout but more so on the left. Her temperature was 105.4 degrees F. Three days later a diarrhœa developed which lasted 3 days.

On May 3 a roentgenogram showed the diaphragm to be at the same level on both sides and also showed a shift of density in the abdomen suggesting free peritoneal fluid but no gas. For the following 2 weeks the patient continued to be quite ill with a constant fever, increased pulse rate, and tenderness of the abdomen.

On May 16 (33 days after admission) a red bulging area was noticed in the upper abdomen. This area was aspirated and found to contain blood and gas. At this time a diagnosis of subphrenic abscess was made. Two days later crepitation was found just above the needle puncture.

On May 20 the patient was operated on through a midline incision in the upper abdomen and gas and 300 cubic centimeters of pus escaped. Culture of the pus showed Staphylococcus aureus and Streptococcus mitior (Holman classification). Two days later the patient vomited and a foul brown discharge came from the wound. The discharge continued to have a foul odor and after 6 days it was found to contain bile. In the meantime, the patient developed measles from which she recovered without any complications (she had previously received prophylactic convalescent erysipelas serum as noted above). On May 29 vomiting set in. It was bloody at times and continued until death occurred 52 days after her admission.

A necropsy showed a chronic perforated gastric ulcer on the anterior wall of the greater curvature of the stomach, a left subphrenic abscess, a generalized peritonitis, multiple abscesses of the lower left lung, bronchopneumonia of the lower right lung, and numerous partial adhesive obstructions of the small bowel. A culture of the pus obtained at necropsy showed Bacillus coli, Streptococcus viridans, and an organism morphologically resembling Bacillus diphtheria but which on subculture was overgrown by other organisms and could not be further identified.

Case 3. C. H., male, aged 14 months, was admitted January 20, 1933, with a temperature of 102.4 degrees F. rectally, and for 3 days had had diarrhœa, and restlessness.

Examination showed the right ear drum to be red and a consolidation of the lower lobe of the right lung which was diagnosed as lobar pneumonia. On January 27 tenderness was noted in the right upper abdomen and a succussion splash could be demonstrated. A roentgenogram showed gas beneath the diaphragm. On the following day it was noticed that the superficial vessels of the abdominal wall were dilated. The abdomen was distended, bulged in the right flank, and a shifting tympany was present as the position of the child was changed. At this time the blood examination showed 3,000,000 erythrocytes, 52 per cent hæmoglobin, and 28,000 leucocytes. The urine showed nothing abnormal.

A diagnosis of subphrenic abscess was made and on February 1 (11 days after admission) the child was operated on under nitrous oxide anæsthesia through a right upper anterior abdominal incision. Some gas and about 400 cubic centimeters of pus were found between the liver and the diaphragm. Cultures of the pus showed Bacillus coli. A rubber drainage tube was inserted.

Following this the patient was quite ill and on March 4 40 cubic centimeters of blood from the mother was injected into the buttock. Improvement occurred gradually and the drainage tube was removed March 11 (39 days after operation). He was afebrile after this and was discharged as cured March 22.

However, he was readmitted June 30 after having been ill for 1 week with a fever, loss of appetite, and tenderness of the right upper abdomen. A diagnosis of recurrent subphrenic abscess was made. He was under observation for 11 days when the abscess ruptured spontaneously through

the old scar. The patient became afebrile July 20 and the discharge had ceased on July 30 (30 days after the second admission).

CASE 4. H. W., female, aged 10 years, was admitted August 28, 1931, complaining of pain in the right upper quadrant of the abdomen of 3 weeks' duration. Anorexia and restlessness had been present for the past 2 weeks.

Eight months before she had had an appendectomy performed elsewhere and 2 weeks later an incision was made in the right lower posterior chest wall to evacuate some pus. The discharge lasted only 2 weeks. From the history and position of the scar, it was thought that the child had had a subphrenic abscess.

On admission to the hospital, an examination of the right side of the chest showed the respiratory excursions diminished and marked tenderness on deep pressure on the lower portion with increased fremitus and dullness in this region. There was a healed scar over the right lower posterior chest in the region of the ninth interspace and another at McBurney's point. Her temperature was 101.6 degrees F. rectally, pulse 110, and respiration 22. Blood examination revealed 74 per cent hæmoglobin and 11,150 leucocytes with 74 per cent polymorphonuclear forms. The urine showed nothing abnormal.

Roentgenograms revealed a marked elevation of the right half of the diaphragm and a diagnosis of recurrent subphrenic abscess was made.

Four days after admission the scar in the right lower chest became tender and red and, under ether anæsthesia, an incision was made into this old scar. Pus was found extending from just beneath the skin to the region between the liver and the diaphragm and a rubber tube was inserted. Cultures of the pus showed Streptococcus hæmolyticus. Eight days after operation the patient became afebrile and on September 22 (25 days after admission) the wound closed and the patient was discharged.

CASE 5. C. D., male, aged 11 years, was admitted to the Presbyterian Hospital August 3, 1931, with vomiting and abdominal pain of 2 days' duration. The pain in the abdomen began in the region of the umbilicus and later became generalized.

Examination showed the abdominal muscles to be tender and rigid throughout, but more so in the right lower quadrant.

The blood examination showed 4,950,000 erythrocytes, 88 per cent hæmoglobin, and 23,600 leucocytes. The urine examination showed nothing abnormal.

A diagnosis of acute appendicitis and generalized peritonitis was made and, under ethylene anæsthesia, the patient was operated on through a right rectus incision. Much pus was encountered so the appendix was not removed, but three drainage tubes were inserted into the peritoneal cavity. The patient remained quite ill and on August 8 a pus pocket was opened through the old appendiceal wound. Later, signs of a pelvic abscess developed and on September 16 the rectal wall was incised and through and through drainage was instituted from the old appendiceal wound and the rectum. A septic temperature developed and on August 29 (26 days after admission), roentgenograms showed elevation of both leaves of the diaphragm. Two days later the right subphrenic space was explored posteriorly in the ninth intercostal space, but no pus was found. On September 9 an incision was made in the epigastric region and gas and pus were found. Culture of the pus revealed Bacillus coli and an anaerobic coccus. Following this the patient improved and was afebrile after November 17. He was discharged December 12 (131 days after admission) with a healed wound.

CASE 6. C. B., female, aged 9 years, entered February 3, 1933, with pain in the right side of the abdomen, cough, vomiting, fever, dyspnœa, and swelling of the left foot.

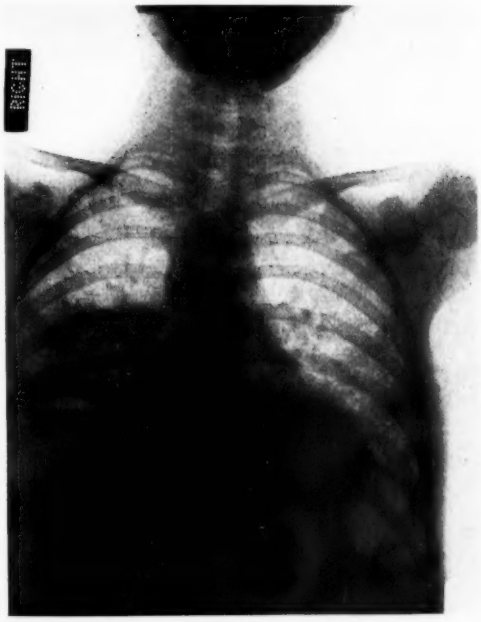

Fig. 1. Case 6. Showing right diaphragm elevated with gas beneath but absence of gas elsewhere in right upper abdomen. Denseness of lower right lung.

Her previous history was negative except for an attack of pneumonia at 7 years of age.

The patient's present illness dated back 1 year when she was treated at home for a few days with the diagnosis of acute bacterial endocarditis. She did not improve at home and entered the Cook County Hospital February 22, 1932, when a diagnosis was made of probable perforative appendicitis. Although she remained there 2 months no definite diagnosis was made nor an operation performed. From this date she was ill at home most of the time until January 31, 1933, when she suddenly developed paralysis of her right hand and a twitching of her mouth both of which lasted for 5 minutes. Four days later she entered the Children's Memorial Hospital.

Examination showed her to be dyspnœic, cyanotic, and acutely ill. The left heart border was 2 centimeters beyond the left nipple line. There was a soft systolic murmur over the mitral area and a slapping second sound over the tricuspid area. The diameter of the right chest was greater than the left and the intercostal spaces on this side bulged somewhat. Litten's sign was negative on the right but positive on the left. The lower lobe of the right lung was dull on percussion and showed an area of cracked-pot resonance with bronchial breathing and bronchophony. The liver edge was palpable at the level of the umbilicus. There was marked clubbing of the fingers and toes.

Her temperature was 105.4 degrees F., pulse 102, and respiration 32. Blood examination revealed 3,250,000 erythrocytes, 60 per cent hæmoglobin, and 14,000 leucocytes. The urine showed ++ albumin.

TABLE I.—SUMMARY OF CASES

Case	Age Sex	Primary disease	Organism	Leucocyte count	Time from primary disease to diagnosis of subphrenic abscess	Operative procedure	Time in hospital till afebrile	Time in hospital	Result
1 (J.P.)	12 yrs. F	Appendicitis	Bacillus	26,000	10 days	Drained posteriorly through the pleura	108 days	148 days	Recovered
2 (M.C.)	2 yrs. F	Chronic gastric ulcer	Staphylococcus aureus and Streptococcus mitior (Holman classification)	21,000	39 days	Drained through anterior abdomen	Died 53rd day	53 days	Died
3 (C.H.)	14 mo. M	Lobar pneumonia	Bacillus coli	28,000	10 days	Drained through right anterior abdomen	1st attack 51 days 2nd attack 30 days	1st attack 62 days 2nd attack 35 days	Recovered
4 (H.W.)	11 yrs. F	Appendicitis	Streptococcus hæmolyticus	11,150	253 days until second abscess	Drained posteriorly through the pleura	8 days	24 days	Recovered
5 (C.D.)	12 yrs. M	Acute appendicitis	Bacillus pyocyaneus and an anaerobic gram positive coccus	23,600	59 days	Drained through anterior abdomen	103 days	127 days	Recovered
6 (C.B.)	9 yrs. F	Acute appendicitis	Streptococcus non-hæmolyticus iii (Holman classification)	28,100	346 days	Drained posteriorly through the pleura	51 days	166 days	Recovered

Roentgenograms showed a clouding of the lower half of the right lung and elevation of the diaphragm with a collection of gas and a fluid level beneath it (Fig. 1). Dr. Anspach, the roentgenologist, interpreted the findings as those of a subphrenic abscess; but others thought they indicated a bronchiectasis or a lung abscess.

From the physical findings of the heart a diagnosis of carditis was made. The patient was so dyspnœic that she was placed into an oxygen tent. On February 5 she coughed up 2 ounces of foul pus and 3 days later the chest was aspirated and 5 cubic centimeters of pus and gas were removed. It was thought that an empyema had ruptured into a bronchus.

On February 11, under local anæsthesia, a costectomy of 1 inch of the eighth right rib was performed and the pleura was opened in the seventh intercostal space. Two ounces of pus were aspirated which on culture showed non-hæmolytic streptococcus iii (Holman classification). This region was packed with iodoform gauze. Four days later a cavity in what was thought to be the lung was opened by cautery and a drainage tube placed into the cavity. February 22 (19 days after admission) she had an attack of blindness which lasted 5 minutes. For the next few days she improved by the employment of postural oral drainage.

The discharge from the thoracotomy wound did not cease, so on March 20 an attempt was made to inject lipiodol into the sinus to determine its extent, but the attempt met with very little success. She was afebrile after 8 weeks. After a period of 5½ months she had practically recovered and was sent to a convalescent home.

Even after this patient had recovered there was still a question of the complete diagnosis in the minds of some who saw her. The elevated right half of the diaphragm with a dome of gas beneath it and a fluid level beneath the gas supported the diagnosis of subphrenic abscess to such an extent that the case was included in this group. It was believed that the patient had a subphrenic abscess which ruptured through the diaphragm forming a lung abscess which in turn ruptured into a bronchus.

Table I is a summary of the cases.

SUMMARY

1. Subphrenic abscess in children is not common. Six cases in children are reported in detail.

2. Four followed acute appendicitis, 1 followed a ruptured chronic gastric ulcer, and 1 followed lobar pneumonia.

3. Three were operated on by the anterior and 3 by the posterior approach.

4. One (16⅔ per cent) of the 6 patients died.

5. Judging from these cases, the clinical course of subphrenic abscess in children differs very little from that of adults.

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URETERO-INTESTINAL ANASTOMOSES

The Use of Mechanical Anastomosing Apparatus

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THE majority of clinical and experimental evidence in uretero-intestinal anastomoses has shown that the reconstruction of the natural valve as devised by Coffey (3) is essential for a good result. The formation of this mucous membrane valve apparently prevents the regurgitation of the contents of the bowel into the transplanted ureter. Although the majority of surgeons provide for the formation of the Coffey valve, their method of introducing the ureter into the lumen of the intestine varies. Coffey has recommended the use of ureteral catheters tied into the ureters at the time of transplantation and brought out the rectum for drainage (4). This method prevents the occlusion of the ureter by swelling and allows bilateral transplantation at the same time. Mayo introduces the ureter into the lumen of the intestine without the use of ureteral catheters followed by transplantation of the opposite ureter at a later date. Although good clinical results have been reported the construction of the Coffey valve has not entirely settled the difficulties resulting from ascending renal infection. Patients frequently give evidence of ascending renal infection while the ureteral catheters are tied in place. This would more or less rule out the lumen of the ureter as the conveyor of the ascending infection to the kidney. The problem of ascending infection to the kidney, therefore, continues to be one of th fundamental problems in the operation of trans planting the ureters into the intestine.

Sweet and Stewart, working on the proble of ascending infection of the kidney, conclude that an extensive network of lymph vessels an channels exists in the mucosa, submucosa, in th external coats of the bladder and ureters, and i the entire structure of the kidney. Also that th lymphatic network of the ureter anastomose freely with the lymphatics of the bladder an kidney. They concluded from their experimenta work that the ascending infection travels throug this lymphatic system and not through the bloo vessels of the ureter or through the lumen o the ureter. Sisk, Wear, and O'Brien, in 1931 reported that transplantation of the ureters t the sigmoid in dogs was a highly unsatisfactory procedure by the Mayo technique. The com pleted tube technique of Coffey gave only slightly better results. They had two animals i which one side was transplanted with the tub technique of Coffey. The kidneys were in good condition but the dogs never appeared well after the operation. They obtained an infected kidney in two dogs by transplanting a ligated ureter. This apparently ruled out the lumen of the ureter as a route of ascending infection. They obtained better results in their experiments by protecting

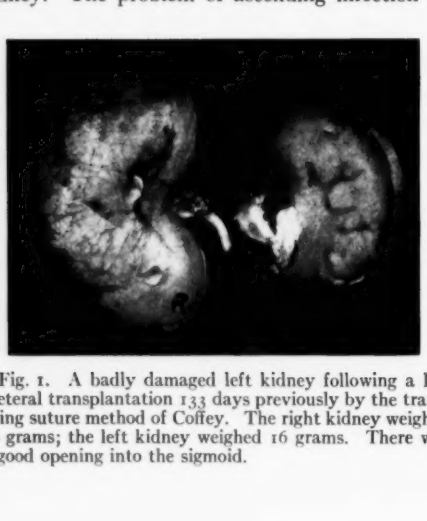

Fig. 1. A badly damaged left kidney following a left ureteral transplantation 133 days previously by the transfixing suture method of Coffey. The right kidney weighed 40 grams; the left kidney weighed 16 grams. There was a good opening into the sigmoid.

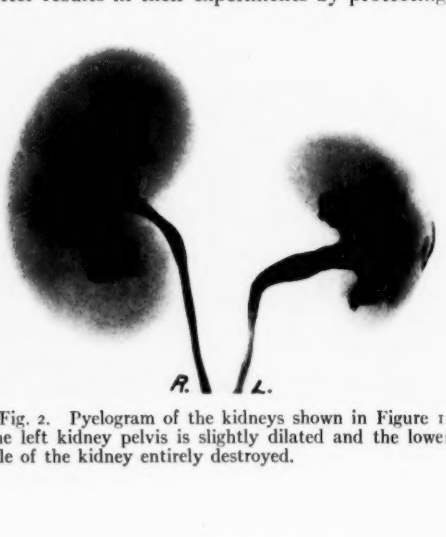

Fig. 2. Pyelogram of the kidneys shown in Figure 1. The left kidney pelvis is slightly dilated and the lower pole of the kidney entirely destroyed.

Fig. 3. Cross section of kidneys 75 days after left ureteral transplantation by the transfixing suture method of Coffey. The left kidney was filled with multiple abscesses.

the end of the ureter for a time from infected material. They believed that the solution of the problem of ascending renal infection probably depended upon the discovery of means to prevent infection through the lymphatics.

Coffey (5) recently advocated a method of transplantation which attempts to protect the end of the ureter. A ligated ureter is buried in a manner to effect a valve but a direct opening into the intestine is not made. A silk suture is so placed through one-half of the ureter and through the intestinal mucosa that when tied tightly it will slough through leaving an ureterorectal fistula. This does not protect the lymphatics entirely as the suture is infected as it is passed through into the lumen of the intestine. In addition, this method does produce a period of obstruction which is not desirable, especially in kidneys which are usually already infected. We have tried this method in a few dogs with varying degrees of success (Figs. 1 to 4). More recently Higgins has described a method of using the transfixing silk suture to effect the ureterointestinal anastomosis, at the same time preventing urinary obstruction. The ureter for a short distance is lifted from its bed and its continuity to the bladder maintained. The mobilized portion of ureter is transplanted into the wall of the sigmoid and a silk mattress suture placed to include the wall of the ureter into the lumen and then through the mucosa of the intestine. This suture is tied quite tightly and will slough out in a short time leaving the uretero-intestinal fistula. At a later operation the ureter is divided and ligated as it leaves the wall of the intestine. The end is covered in the wall of the sigmoid and the vesical end allowed to remain or be removed with the bladder in cases of bilateral transplantation. This method should be an improvement on the transfixing suture method as described by Coffey. However, the silk suture is contaminated and the lymphatics are immediately exposed to infection. In addition, a second operation would be necessary to complete the anastomosis. The author states that he has used the method with most satisfactory results in 7 patients. No definite experimental results are given.

Experimentally better results have been obtained by making an effort to protect temporarily the end of the ureter from infection as the

Fig. 4. Bilateral transplantation by the transfixing suture method of Coffey. An excellent kidney was obtained on the right side which had been transplanted for 145 days. A large hydronephrotic kidney was found on the left side which had been transplanted 85 days. There was no communication with the sigmoid.

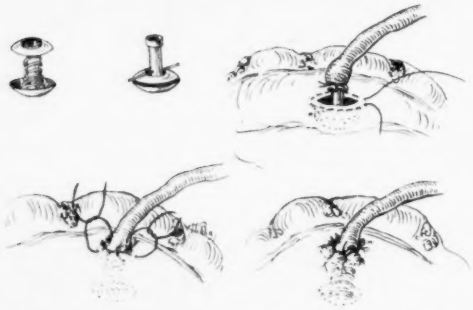

Fig. 5. Drawing showing the Boari buttons. A direct implantation into the intestine was made.

lymphatics apparently play a definite part in the ascending infection to the kidney. The end of the ureter therefore should be protected from infection for a sufficient period to allow for occlusion of the lymphatics and at the same time permit the escape of urine. This can be accomplished by a mechanical device which allows an aseptic transplantation of the ureter and at the same time permits the escape of urine. By such a method the preparation of the patient would be greatly simplified, the dangers of contamination at the time of operation avoided, and the open lymphatics protected from immediate exposure to infection.

A mechanical device for the transplantation of ureters was introduced in 1895 by Boari, an Italian surgeon (Fig. 5). The buttons were made in various sizes. The drawings show the principle on which it worked. The button would slough out in a few days and pass by rectum. When the ureter was implanted into the bladder of males it was necessary to remove the button by cystotomy. He reported a good result following the transplantation of the left ureter into the descending colon in a case of vesicovaginal fistula. Cosati, in 1895, used the Boari button to transplant the left ureter in an advanced case of vesical tuberculosis. The patient lived for 35 days. Turetta, in 1899, did a bilateral ureterorectal anastomosis with the use of Boari buttons but the patient died on the sixteenth day after operation. Of course in these cases the ureter

Fig. 6. Drawing showing the hollow nickel tube described and used by Chalot.

was directly implanted into the intestine and no effort made to cause the reproduction of a natural valve.

Another mechanical device was designed and successfully used by Chalot in 1896. He designed a hollow nickel tube with cone-shaped ends (Fig. 6). The tube was 3.5 centimeters in length and its inside diameter measured from 1 to 3 millimeters. One and one-half centimeters from one end there was a groove large enough to receive a loop of thread, which was tied around the end of the ureter after it had been slipped over the smaller end of the tube. The rectal end of the tube was perforated to allow attachment of a thread by which the cylinder could be withdrawn later. The patient was living a year after bilateral ureterorectal anastomosis had been performed.

Poth has recently proved experimentally the value of using a small metal cannula for performing cysticoduodenostomy. He states that it has been successfully applied to the transplantation of pancreatic ducts and ureters, giving a rapid technique for anastomosing small ducts into larger, hollow viscera.

Several types of mechanical appliances were tried before a method was devised which allowed a sterile transplantation of the ureter into the rectum and at the same time permitted the escape of urine. The methods were varied frequently but it was possible to transplant a ureter successfully by such a method. Although the instruments to be described and the results obtained can be greatly improved the method is reported in the hope that further work may be done, which will indicate advantages in the use of such a method in patients.

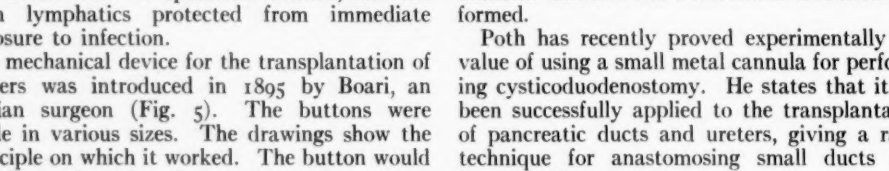

Fig. 7. Cross section showing the small dress snap in place and after sloughing into the rectum.

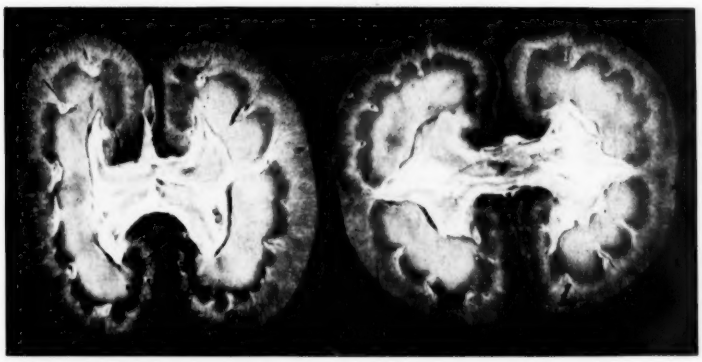

Fig. 8. Left side transplanted by the dress snap method 119 days previously. The left kidney weighed 42 grams. The right kidney weighed 45 grams.

EXPERIMENTS

All experiments were conducted on dogs. The animals were given a cathartic consisting of 30 cubic centimeters of castor oil on the day previous to operation. All food was withheld the day of operation and the rectum cleansed with several soap suds enemas. The animals were given a preliminary hypodermic of 0.015 grams (or 15 milligrams) of morphine previous to the induction of ether anæsthesia. The abdomen was shaved and the skin cleansed with alcohol and bichloride of mercury solution. The abdomen was opened through a low midline incision in the female animals and a muscle splitting incision in the male animals. The left ureter was transplanted in the majority of our experiments.

An enlarged model of a dress snap was used in the first group of experiments (Fig. 7). The male portion of the button was about one-quarter of an inch in height. A hole was made in the base of the snap to allow a heavy thread to be tied through it. This part of the button was then inserted into the cleansed rectum with a long clamp to hold it in place. The thread was long enough to protrude from the rectum. The abdomen was opened under sterile conditions, and the ureter prepared for transplantation. The female portion of the button was then anchored by several fine catgut sutures to the end of the ureter. The wall of the sigmoid was prepared by making an incision through the muscularis down to the mucosa for a distance of about 1.5 inches. At this point the male portion of the snap in the lumen of the sigmoid could be easily palpated. An unsterile assistant loosened the clamp holding the button in the rectum allowing it to be brought up into position with the thumb and index finger of the left hand (Fig. 14). The mucosa over the button was sponged dry and the female portion of the button fitted just close enough to allow for the extra thickness of the mucosa. The muscularis was then closed in two layers after the method of Coffey. From 3 to 7 days later the snap was either passed by rectum or could easily be pulled out by the silk suture protruding from the rectum (Fig. 7). A good kidney was obtained in 3 of the 5 dogs in which this method was used. In one of our failures a small dog was used and the end of the small ureter was severely traumatized at the time of operation. There was no opening into the sigmoid in this animal. The opening into the intestine was quite large in the three good results. The animals were allowed to survive 29 days, 58 days, and 119 days (Figs. 8, 9, 10). Although good experimental results could probably be obtained in large dogs by this method it does

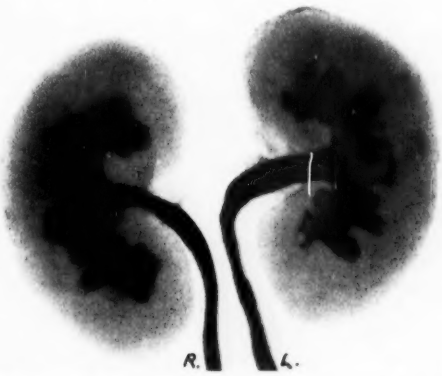

Fig. 9. Pyelogram of kidneys shown in Figure 8. The left kidney pelvis is slightly dilated.

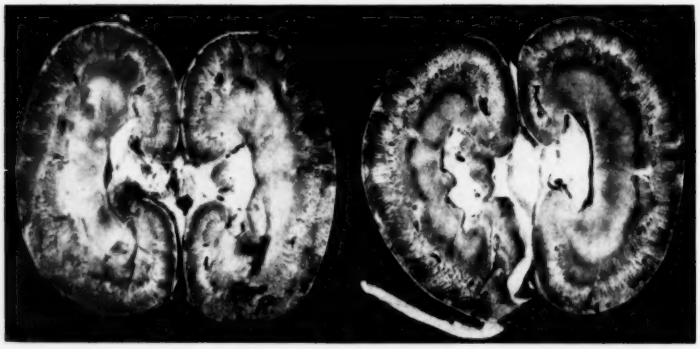

Fig. 10. The left side transplanted by the dress snap method 29 days previously. Each kidney weighed 38 grams.

give a period of urinary obstruction which makes its use prohibitive in patients.

An attempt was made in the second group of experiments to insure an aseptic transplantation and at the same time permit the end of the ureter to protrude more into the lumen of the intestine. Small rectangular metal boxes were used varying in size from one-half to one inch in length and about one quarter to three-eighths of an inch in width. The male part of the box was inserted into the rectum as in the first group of experiments. At one end of the female part of the box a small metal gooseneck projection was placed which would pass into the lumen of the ureter and allow the ureter to be anchored about its base. It was hoped that the end of the ureter would project for some distance into the sigmoid following the passage of the box which gave a rectangular opening in the mucosa beneath the end of the ureter. Although several good results (Figs. 11, 12) were obtained by this method, the majority were badly damaged kidneys or, more frequently, there was no communication with the lumen of the sigmoid. The box was too large and a slough of the muscularis covering it frequently occurred resulting in peritonitis. The opening through the mucosa was also entirely too big, thus making this method unsatisfactory.

It became obvious from the early experiments that the opening into the mucosa must be kept quite small. Furthermore, no provision had been made to permit the escape of urine. The final group of experiments were carried out with varied modifications of the button shown in Figure 13. The cross section of the button in place demonstrates how it permits the urine to reach the outside immediately after the button has been pressed together. The male portion of the snap with attached catheter is inserted into the rectum and held in position by a long dressing forceps.

After the abdomen has been opened and the mucosa prepared, the button is grasped by the thumb and forefinger (Fig. 14), and the clamp in the rectum is released by the unsterile assistant. The button in the cleansed rectum is always easily identified and brought into place. The unsterile assistant then injects water through the catheter projecting out the rectum to wash away any material which might occlude the opening of the pointed catheter in the snap. This also washes foreign material from the mucosa over the button which might prevent proper approximation of the two parts. The sterile portion of the button, with a small catheter attached and sutures passed through the top of the button for anchorage of the ureter, is then pressed into position. An attempt has been made to allow just room enough for the mucosa to be pinched tightly but not entirely cut at the time of transplantation. It must be admitted that as yet the buttons have not always been satisfactory in holding together. Another model should be constructed which would screw the parts together and absolutely prevent their separation at the time of operation as well as at the time of sloughing through into the rectum.

About 6 inches of the end of a No. 7 whistle-tip catheter is usually used on the sterile portion of the button. After the parts have been pressed together, sterile saline is injected into the catheter to make sure a free communication exists with the outside. The unsterile assistant collects the fluid to make sure of a return flow through the catheter in the rectum. The short catheter is then threaded into the ureter and the end of the ureter anchored to the button by several of the fine catgut sutures pre

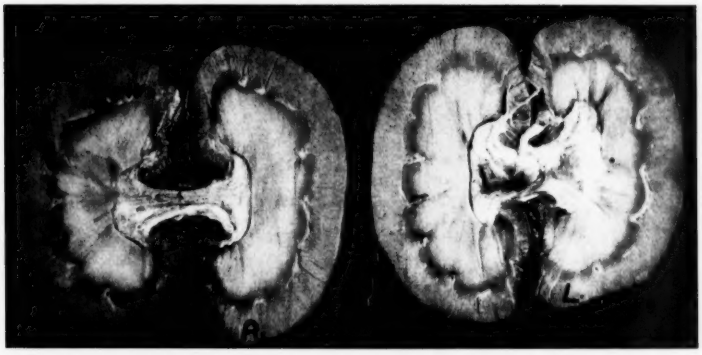

Fig. 11. The right ureter transplanted for 70 days using a small metal box. The right kidney weighed 55 grams. The left kidney weighed 60 grams.

viously placed through the button (Fig. 15). In later experiments the end of the ureter was split about one-quarter of an inch to prevent so much injury and resultant sloughing of the end of the ureter after it was sewed down to the button. In addition, the flat end of the divided ureter could be anchored to the mucosa just beyond the button (Fig. 16). This prevented it from slipping upward following the removal of the button. A viable ureter would also be present beyond the small opening where the button sloughed through the mucous membrane. The muscularis was closed in the usual fashion by the use of fine continuous catgut or interrupted silk sutures (Figs. 17, 18).

Immediately after operation the animals were given 500 to 1,000 cubic centimeters of normal saline intravenously. Usually this prompted a rapid flow of urine from the catheter protruding from the anus. The catheter was allowed to protrude from the anus about 1 to 2 inches. Occasionally the animals would bite the catheter and pull the buttons apart, thus ruining the experiment. The administration of intravenous saline was continued for a week or more. It is probably more important to force fluids immediately after the button comes out than while in place, because of the contact of the ureter at this time with intestinal contents and possible occlusion of the lumen of the ureter following removal of the short catheter. The catheter should be inspected rather frequently to insure a continuous flow of urine. The flow of urine can usually be started following suction with a large syringe and a needle inserted into the catheter extending from the anus. Several of our early experiments were complicated by injecting mercurochrome or saline up the catheter to start the flow of urine, and grossly contaminating the lumen of the ureter. Immediately following this injection the animals developed a high temperature and usually died.

The drainage button was varied several times in an attempt to make the anastomosis easier and improve the results. Several good kidneys (Figs. 19, 20) were obtained in the first experiments in which a rather large button was used and a doughnut-shaped piece of mucosa cut out at the time of operation. This gave too liberal an opening into the mucosa and sloughed out within 2 days which was apparently too early for persistently good results. The technical part of uniting the button was made much easier by making the metal opening in the rectal part of the button quite large. The metal catheter in the sterile part of the button could then be easily pushed into place. This telescope drainage button apparently produced too large an opening into

Fig. 12. Pyelogram of kidneys shown in Figure 11. The right pelvis is slightly dilated.

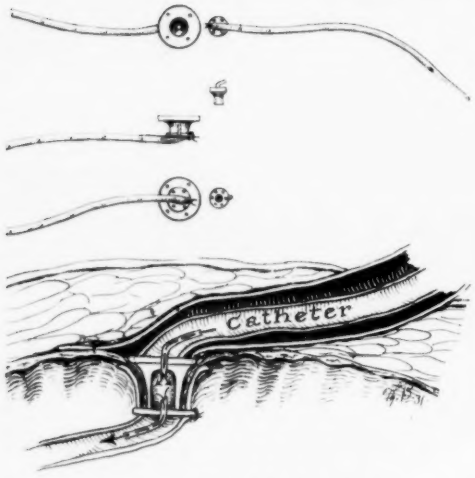

Fig. 13. Cross section of the drainage button.

Fig. 14. The part of the button placed in the rectu is brought up and held beneath the mucosa between th thumb and index finger. The sterile portion of the butto and catheter is ready to be pressed into position.

the mucosa and the results were poor. The best results were obtained by using a drainage button patterned after the first one used, only much smaller (Fig. 13). Sufficient space was allowed between the two parts of the button to permi the mucosa to be snugly compressed but no immediately cut. This made the button remai in place over a longer period of time. With dogs

Fig. 15.

Fig. 16.

Fig. 15. The button in place with communication through catheters to the outside. The ureter is being drawn down to be sewed to the button.

Fig. 16. Drawing showing the split end of the ureter which is anchored to the button and as well to the mucosa beyond it. The latter suture does not, however, enter the lumen of the intestine.

Fig. 17.

Fig. 18.

Fig. 17. Closure of the muscularis over the ureter. It is not necessary for the wall of the ureter to be included in the suture when it is anchored beyond the button.

Fig. 18. Drawing showing the second layer of sutures which are made to approximate the muscularis over the ureter.

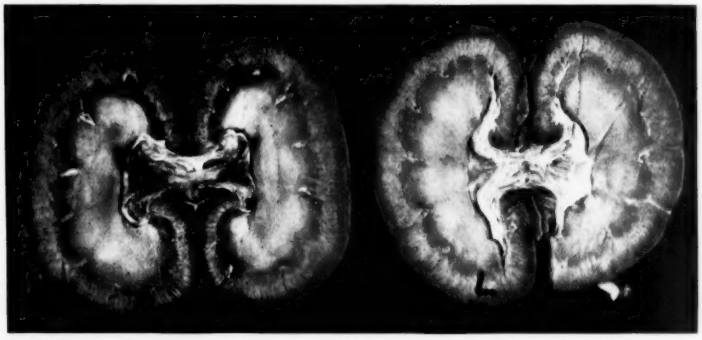

Fig. 19. One of the early experiments in which the drainage button was used. The left ureter was transplanted 30 days previous to sacrifice of the animal. The left kidney weighed 60 grams. The right kidney weighed 70 grams. The phenolsulphonephthalein function test gave an output of 20 per cent in 15 minutes on the right side compared to 18 per cent on the transplanted side.

however, it was difficult to keep the apparatus in place over 2 to 3 days, which is an insufficient period of time. It would be comparatively easy in patients resting in bed to keep the button in place a week or even longer. The dangers from pulling out the protruding catheter would be obliterated, the fluid intake better controlled, and a closer check could be maintained to avoid obstruction to the system. The button would be made several times larger for use in patients, which would no doubt rule out a great part of the difficulty resulting from the occlusion of the small tubes which must necessarily be used in animals.

The small drainage button was used in 18 dogs. One animal died of distemper 19 days after operation, and the kidney on the transplanted side was in very good condition. A good result was obtained in 6 animals, or 35 per cent of the remaining 17 animals (Fig. 21). There was a large opening of the ureter into the sigmoid in these cases. Five of the 11 failures could be definitely traced to correctable errors at the time of operation or immediately afterward. The end of the ureter was ruined in 2 animals by an attempt to pull the ureter down over too large a catheter.

Two failures were in experiments in which the suture line in the sigmoid was rotated and anchored to the side wall of the pelvis. Apparently this twisted the ureter and injured its blood supply as it was sealed off as it entered the wall of the sigmoid. The split end of the ureter was sewed to the small metal tube without the use of the catheter in 2 cases in which good results were obtained. A prognosis could usually be made after the first week following the operation.

A consistent elevation of rectal temperature above 39 degrees C. generally indicated infection

No.	Ureter transplanted	Survival days	Weight of kidney		Phenolsulphonephthalein per cent		Result
			Right	Left	Right	Left	
A	Left	136	44	46	15	15	good
B	Left	108	56	52	10	7	good
C	Left	156	52	46	15	17	good
D	Left	94	50	44	15	15	good
E	Left	90	41	42	not	done	good
F	Left	90	47	41	12	7	good

Phenolsulphonephthalein administered in 1 cubic centimeter dose. Urine collected for 15 minutes following appearance of dye.

Fig. 20. Pyelogram of the kidneys shown in Figure 19. The left ureter and pelvis are moderately dilated.

Fig. 21.

of the kidney and a poor result could be expected. The animals lost some weight following the transplantation and usually carried a moderate elevation in temperature. A diarrhœa was often found to be present.

SUMMARY

Previous experimental evidence indicates that better results can be obtained in uretero-intestinal anastomosis if the ureter is temporarily protected from contamination. Contamination of the open lymphatics of the ureter at the time of operation is probably a major route of ascending infection to the kidney.

A mechanical appliance is described which answers the experimental requirements for protection of the ureter and which permits the immediate aseptic drainage of urine.

A review is given of the previous mechanical appliances used in ureteral transplantation. The mechanical efficiency of the drainage button described can be greatly improved by changing the design to such a degree as to allow the parts to screw together, thus preventing their separation.

It is suggested that a much larger drainage button of such a design could be advantageously used in patients with good results.

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PECTENOSIS AND MINOR MALADIES OF THE ANAL REGION[1]

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MINOR maladies of the anal region are a fruitful cause of discomfort and embarrassment to both patient and physician, as may be judged by the numbers who seek relief at the hands of the specialist and in the clinic, and further by the diversity and multitude of procedures which have been advocated and employed for their relief. Apart from the patient's physical affliction, the psychological effect of the condition is often of such importance as to amount to a neurosis. It is this mental state associated with anorectal lesions, and the difficulty which the physician experiences in ameliorating what seems to the patient to be a comparatively trivial, though none the less real, lesion, which often makes these patients difficult to handle and complicates the treatment.

The purpose of this paper is to draw attention to the importance of a variety of lesions found in the anal canal and to record some personal observations as to their clinical findings and treatment. Many of these lesions have a common etiological basis in what Miles has called "Pectenosis." Pectenosis does not seem to have received, in this country, the attention that it deserves.

It is necessary at this juncture to consider certain preliminaries in the nature of the anatomy and physiology of the lower end of the alimentary tract; preliminaries nowhere of more importance for a correct appreciation of the many and varied pathological lesions which occur in this region.

The current descriptions of the anatomy of the anal canal found in modern textbooks of anatomy and proctology are frequently incorrect. As often happens, pathological investigations lead to a closer examination of anatomical detail and bring to light points which traditional descriptions have neglected, or but cursorily mentioned. It is these points which are essential for what follows and for the correct interpretation of certain anorectal lesions.

For purposes of study and teaching, we prefer to think of the anal canal as presenting four landmarks, namely: (1) the anocutaneous line; (2) the white line of Hilton; (3) the pectinate line; (4) the anorectal line (see illustration).

1. The anocutaneous line marks the lower end of the gastro-intestinal tract. Stratified squamous epithelium is found on both sides of this line. It is easily identified, however, because no hair follicles and but few sweat glands are to be seen cephalad to this margin. The epithelium above this line is usually thrown into folds by the action of an involuntary muscle, by some termed the corrugator cutis ani. This muscle represents the lower medial end of the longitudinal muscle of the bowel which also forms the sheath of the sphincter ani externus.

2. The white line of Hilton lies 1.5 centimeters above the anocutaneous line. Hilton in his classical description of this landmark in 1863 described this line as "white"; this is so in the cadaver, but in the living subject the line is decidedly blue in color. This area, he believed, corresponded to the division between the hind-gut and proctodeum. In 1896, Stroud, a physiologist, was impressed by the fact that all of the surface area cephalad to the white line and limited by the pectinate line above, was lined by transitional epithelium. It is, therefore, neither skin nor mucosa. This area is somewhat irregular in breadth, varying from 6 to 9 millimeters. The surface is smooth and has a glossy, shining appearance. Its general form may be likened to that of a saw with irregular teeth pointing upward. The dentations interdigitate with those of the rectal columns of Morgagni to form the so called anal papillæ. The appearance of this area, with its dentations, led Stroud to call this region the pecten, from its resemblance to a comb. (L. pecten.)

3. The pectinate line is represented by the lower margins of the sinuses and columns of Morgagni. This line marks the location of the anal valves and anal crypts, the latter opening into the recesses between the lower ends of the sinuses of Morgagni. This line is also called the valvular line and also the dentate margin. This landmark is readily identified and is important, for the majority of the lesions with which we deal occur in its vicinity.

4. The anorectal line is 1.5 centimeters above the pectinate line. Its exact position can be identified only with the aid of a microscope. Histologically, that portion occupied by the rectal columns, the upper two-fifths of the anal canal, is lined by cuboidal epithelium and the rectum above by deep columnar epithelium. The transition is abrupt and it is this change which marks the division between anus and rectum. The anorectal junction, so formed, lies one and one-ha

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inches above the anocutaneous line when the anal canal is empty.

In descriptions of this region the term mucocutaneous line or junction is frequently applied. This term, it is apparent from the foregoing should not be used, for it can be applied to designate several different levels of the canal and is therefore ambiguous. As we have seen, the pectinate line indicates the lower end of the mucous membrane.

The pecten is a very important area. Here is a "divide" separating blood supply, lymphatic drainage, and innervation. It is, indeed, a physiologic threshold. The middle hæmorrhoidal vessels fail to send adequate blood supply to the part and it therefore depends upon the anastomoses from above and below for its arterial supply and venous drainage.

When the anal orifice is closed the pecten forms the central part of the floor of the rectal ampulla. It is reasonable to suppose that it should be the seat of special sense organs whose function is to regulate the action of the sphincter muscles. The nerve mechanism is extremely complex. It may be explained by dividing the muscles into two groups, voluntary and involuntary, the action of these two groups being complementary and antagonistic. The voluntary muscles are the sphincter ani externus and the levatores ani. The involuntary muscles are the sphincter ani internus, the corrugator cutis ani, and the important longitudinal muscle of the bowel. The voluntary muscles act through the cerebrospinal nerves with impulses initiated in the cortex. The involuntary muscles are under the control of the sympathetic and parasympathetic systems. There is here an overlapping of a series of complex reflexes, interference with any one of which will bring about an upset in the nicety of balance and increase any pathological process occurring in this region.

The voluntary mechanism of the lower intestinal tract has by far the major rôle in the initiation of the act of defæcation. Normally the rectum is empty, and it is not until the ampulla receives a portion of the fæcal mass that the voluntary mechanism is called upon. Interference with the functional processes of the sympathetic and parasympathetic systems may cause either an inhibition or an overstimulation of peristalsis. This I believe explains why habits, diet, exercise, and psychic influences almost entirely dominate the process of fæcal excretion. There is however an intimate relationship between the voluntary and involuntary actions. As long as the normal balance between the several sphincters is maintained, the physiologic functions are normal; but if the reflex

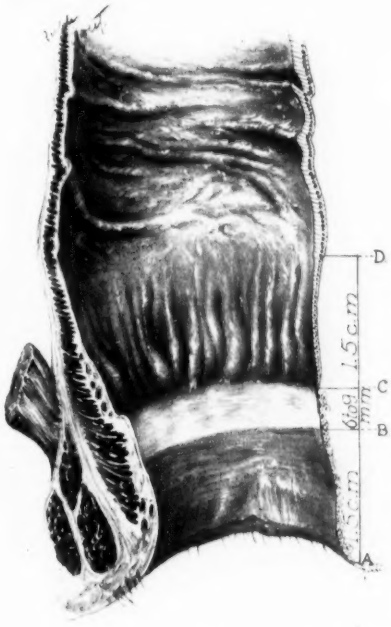

Fig. 1. Anatomical drawing of the anal canal showing the musculature and surface landmarks. *A*, The anocutaneous line; *B*, the white line of Hilton; *C*, the pectinate line; *D*, the anorectal line; *B-C*, the pecten.

arc is disturbed by the failure of any component part, the normal tone of the muscles is upset. The muscles either become atonic or they are thrown into a state of hypertonicity or spasm. Both of these conditions may be present at the same time. This may lead to passive congestion, the principal etiologic factor in many anal maladies.

Chronic passive congestion, as elsewhere, leads to round cell infiltration, the laying down of fibrous tissue in the submucosa, cicatrization, and the production of a condition which is termed pectenosis. Pectenosis, therefore, may be defined as a pathological condition in which a circular deposit of fibrous tissue occurs in the submucosa of the pecten—that area of the anal canal which we have previously defined as being bounded below by the white line of Hilton and above by the pectinate line. This condition was first described by Ernest Miles in a paper published in 1918, and since by Abel in 1932. The fibrous deposit takes the form of a ring which encircles the canal and was called by Miles "the pecten band." It varies both in breadth and thickness according to its duration. It is usually about one-third of an inch broad and

TABLE I.—PECTENOTOMY IN ADDITION TO THE USUAL EXCISION, ETC.

Diagnosis	Cases
Anal fissure	26
Internal hæmorrhoids	19
Pruritus ani	14
Anorectal fistula	14
External hæmorrhoids	8
Tight orifice with rectal constipation	2
Total	83

one-sixth of an inch thick. It can be felt distinctly by compressing the anal margin between the finger in the anus and the thumb outside. In well marked examples it may be compared to a rubber umbrella ring surrounding the anus. Pectenosis is said to be analogous to the formation of fibrous tissue in the submucosa opposite the cricopharyngeus muscle in globus hystericus (McKenzie, 1918; Abel, 1929). In 7 of our cases a wedge-shaped section of the band was removed and sent to the pathologist for histological examination. In 5 of these the slides demonstrated "dense fibrous tissue." In 2 the pathologist reported "*unstriated* muscle with fibrous tissue." These reports disarm any criticism that the band divided was the external sphincter and indicate the true nature of this deposit.

Passive congestion may result from a variety of causes; e.g., varicoses of the hæmorrhoidal veins, contusions or lacerations from the passage of hard, fæcal masses, ingested foreign bodies, irritating liquid stools, etc. The resulting pectenosis may be compared to the fibrosis at the periphery of a varicose ulcer of the leg. Avascularity, loss of elasticity, rigidity of the anal wall, and mechanical obstruction ensue, all factors related to the development of anal fissure, hæmorrhoids, or abscess. Pectenosis, likewise, is often present in pruritus ani, sometimes precedes the development of rectal constipation, and may be associated with spastic colon.

In the past year and one-half I have operated upon 83 patients whose lesions could be explained by the presence of pectenosis and a pecten band (Table I). In some this was incidental, but in the majority it seemed to be the primary factor. Attention is drawn to the variety of conditions which are founded on a common basis.

In each case the band was completely incised. When this is done the free ends of the band retract, the orifice relaxes, and, after several months, when improved circulation is established the fibrosis is absorbed. It is not necessary to excise the band.

The characteristic white fibrous tissue seen at the base of a fissure is always a part of the pecten band. In the operation for fissure it is seldom necessary to incise any of the fibers of the external sphincter. It is, of course, possible to cut the external sphincter without dividing the band. Recurrence of fissure following operation is often due to the fact that the band has not been completely divided. One of our patients was a Chinese boy of 22 with a typical deep posterior fissure of several months' duration. A definite pecten band was demonstrated and was divided through an incision to the left of the midline. As an experiment the fissure as such was not dealt with. Following the pectenotomy the orifice was well relaxed and in 3 weeks the fissure was healed. We do not advocate simple division of the band in fissure, but combine excision with pectenotomy.

In operating upon anorectal conditions one often has difficulty with a narrow orifice, and most surgeons therefore practice divulsion as a routine procedure. This is always dangerous. It produces multiple contusions and may result in the development of hæmatomata and abscesses, but the harm lies mainly in the tearing of the underlying tissue or even the bowel wall itself, producing further fibrosis and associated congestion and, as a consequence, the creation of a vicious circle which still further devitalizes the part, to say nothing of the possible damage to the delicate nerve plexuses which, as we have seen, must play an important rôle in the maintenance of the balance which is so necessary for perfect function.

In this regard it is interesting to speculate as to the relationship of nerve development to anorectal lesions. Anal papillæ, peculiar to man, are said to be present in 40 per cent of people. They consist chiefly of nerve fibers and ganglion cells and are said to constitute accessory sense organs. These anal papillæ have been present in the great majority of our cases of pectenosis.

Pruritus ani is a frequent symptom of pectenosis and some of these patients can be cured only by pectenotomy. Venous stasis results in an inadequate blood supply to the perianal skin. The skin is thickened and the hypertrophy sometimes takes the form of radial folds with deep recesses. The congestion of the mucous membrane above results in increased secretion of mucus which in turn bathes the skin with an irritating liquid. Scratching and rubbing of the part, together with the usual over treatment and improper hygiene, complete the necessary factors for a miserable existence.

From the foregoing pathological studies we can see that relief from pectenosis may be expected from simple section of the band. Many such patients have been cured by divulsion but, as sug

gested, the patient may be left with a condition far worse than he had originally.

The operation is usually performed with the patient in the left lateral Simms position or the lithotomy position. For our purposes the residual intrathecal anæsthesia of Hassler is preferred. Forty to 50 milligrams of procaine hydrochloride, dissolved in 1 cubic centimeter of spinal fluid is slowly injected into the second or third lumbar interspace. This is given with the patient in the sitting posture and he is made to sit up for at least 3 minutes thereafter. This gives a "saddle" anæsthesia of the perineum without affecting the outer thighs and legs, and there is seldom any change in blood pressure. These patients rarely have headaches and they are free from the postoperative discomfort in the lower limbs which is so common in complete spinal anæsthesia. In those patients who need only a simple section of the band, local nerve block of the perineal branches of the fourth sacral nerves in the anococcygeal body has been found to be quite adequate. Occasionally the use of gas and oxygen is indicated.

The band may be incised in any part of its circumference but we prefer the posterior segment at a point just to the left of the midline (5 o'clock). A radial incision, parallel with the long axis of the bowel is made with a knife. It extends upward for about 2 centimeters from a point just below the anocutaneous line. This incision should end at the pectinate line so as to avoid the mucosa because of the danger of injuring the superior hæmorrhoidal artery or its branches. The incision is superficial. The fibrous band is identified and a straight artery forceps is forced through the epithelium at the pectinate line. The blades of the forceps are separated and the band is completely incised. Immediately the orifice is relaxed and the mucosa is everted. Other lesions can then be dealt with. Bleeding points are ligated. No sutures are applied. A small wick of vaseline gauze is placed in the anus and a tight perineal pad is applied. This procedure differs from that of Miles who has his patient in the right Simms position and who inserts his finger into the anus, everts the anal margin with his thumb on the perianal skin and makes an incision over his finger. We find it easier to identify the band with the aid of blunt dissection.

The bowels are confined for 2 or 3 days with the aid of mistura catechu compound. Two sitz baths daily are ordered, beginning the day following the operation. The wound heals by granulation in from 10 days to 2 weeks.

SUMMARY

1. Many minor maladies of the anal region have a common etiological basis in pectenosis.

2. Pectenosis is a pathological condition resulting from passive congestion and results in a fibrous ring in the submucosa of the anal canal.

3. The practice of divulsion is always dangerous.

4. Pectenotomy is the method of choice and has alleviated a variety of lesions, founded on a common basis, pectenosis, as evidenced in an experience of 83 cases.

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EPITHELIOMA OF THE LOWER LIP

Results of Treatment

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THE relative value of different therapeutic agents employed in the treatment of a given condition can be determined only by observation and study of the results obtained over a considerable period of time. Often a new form of treatment is enthusiastically heralded as almost specific, whereas within a few years it is entirely discarded. Often, too, a given form of treatment will continue in popular use for a much longer time than its efficacy justifies. Of the different forms of treatment used for carcinoma of the lip, excision, irradiation, electrocoagulation, and escharotics are most widely employed. Opinions concerning the effectiveness of these agents vary greatly, and it was with the object of securing definite data regarding some of them that this study of the results of treatment was undertaken.

From January 1, 1920, to January 1, 1930, surgical measures, supplemented by treatments with radium and roentgen-rays were used at The Mayo Clinic in cases of epithelioma of the lower lip. A review of the cases was undertaken in order to determine not only the end-results of treatment, but to ascertain the value of this supplementary treatment. Reports on the treatment of carcinoma of the lip from an entirely surgical standpoint, and other reports from a purely radiological standpoint, have appeared in the literature from time to time, but comparison of the observations of different writers is more or less unsatisfactory, especially in view of the fact that microscopic data commonly are entirely lacking in the group in which treatment is not surgical.

During the period under consideration, a total of 1,310 patients with epithelioma of the lower lip were examined in the clinic. In 337 of these cases no treatment was carried out because of the hopelessly advanced stage of the disease. In 31 of the cases treatment was entirely by means of radium and roentgen-rays, either because of the extent of the growth or the advanced age and poor general condition of the patient. In the 942 remaining cases treatment was either entirely surgical or was surgical supplemented by irradiation. These cases form the basis of the present study.

Carcinoma of the lower lip, because of its prominent situation, characteristic appearance, the fact that it early produces symptoms that lead the sufferer to seek relief promptly, and because of the ease with which the local lesion and the lymph nodes draining the region can be removed, should not only be recognized early, but treatment should, with very few exceptions, result in complete cure. Many factors, however, tend to react against this almost ideal situation and lower the percentage of cases in which the disease is entirely eliminated. Some of these factors are the fault of the patient; others, no less important, must be charged against the medical profession. Among the former may be mentioned ignorance, indifference, procrastination, and self-treatment. The latter include lack of experience on the part of the physician, incomplete treatment, and improper treatment. It has been stated that the medical profession is responsible for more carcinomata of the lip reaching an inoperable stage than the public, and, while this is probably an exaggeration, it is not without some foundation.

INCIDENCE

The vast majority of epitheliomata of the lower lip occur among males. The incidence of the disease among females in groups of cases reported by different authors has ranged from 1 to 12 per cent. In this series of 942 cases, only 11 patients (1.15 per cent) were females, whereas 931 (98.8 per cent) were males. The disease belongs primarily to the degenerative period of life, as by far the majority of sufferers are past middle age. In this group, 76.9 per cent of the patients were between 40 and 70 years of age; more than 65 per cent were past 50 years, and only 12.1 per cent were less than 40 years of age. The average age of the patients of the entire group was 54.3 years; of the males 54.4 years, and of the females 47.9 years. The distribution by age groups is shown in Table I. Since the termination of the period during which this group was observed, a boy aged 13 years, with a primary squamous cell epithelioma of the lower lip has been given treatment in the clinic.

All of the lesions included in this series were squamous cell epitheliomata which had originated

primarily on the vermilion border of the lower lip; the basal cell or the squamous cell epitheliomata that developed on the cutaneous surface of the lip and secondarily extended beyond the mucocutaneous margin were not considered nor were the lesions that originated inside the cheeks or on the jaws, and later involved the lower lip, considered. The epitheliomata of the upper lip were likewise excluded. During the period of 10 years, 25 cases of primary squamous cell epithelioma of the upper lip were encountered, also 22 cases in which squamous cell epitheliomata originating on the cutaneous surface of the upper lip secondarily invaded the vermilion border.

In 50 cases (5.3 per cent), 2 or more distinct and separate epitheliomata of the lower lip were present at the time the patients came for treatment. Regardless of the plurality of lesions with which some patients were afflicted, each patient is considered to represent a single case. Moreover, in each of 30 cases (3.1 per cent) an entirely new epithelioma developed on another portion of the lip of a patient who had been well for about 5 years following removal of the original growth. Each of these patients also is taken to represent a single case, but as the new lesions were definitely not recurrences they were not considered as such when the statistics were being compiled. Evidence of marked malignant tendencies in the tissues of some of these patients generally is shown by the fact that in 55 cases (5.8 per cent) malignant tumors other than those on the lower lip were present at the time of examination. These included lesions of the skin, the buccal cavity, tongue, stomach, intestine, and rectum. A number of the patients cured of carcinoma of the lip subsequently died because of an entirely unrelated malignant condition elsewhere in the body.

TABLE I.—AGE INCIDENCE

Years	Patients	Per cent
15–19	1	0.10
20–29	20	2.12
30–39	100	10.62
40–49	207	21.97
50–59	256	27.18
60–69	262	27.81
70–79	88	9.34
80–84	8	0.85

DURATION

The lesions of the lip dealt with in this series varied greatly in duration, appearance, activity, and extent. Some had been present only for a few weeks; others had existed for several years. The patient's statement must be accepted in this regard, and, as is well known, this is often unreliable even when pertaining to a lesion as conspicuous as an epithelioma of the lip. On this basis the average duration of the lesions to the time of examination of the patients in the clinic was 28.3 months. It was anticipated that the average duration of the growth on the lip would be found to vary inversely with the grade or activity of the lesion, but there was less regularity in this regard than was expected. The average duration of the lesions of grade 1 was 24.3 months, and lesions of grade 2 had been present for 29.5 months; those of grade 3 for 35.2 months, and those of grade 4 for 14.7 months. This, of course, does not mean that epitheliomata of the activity noted had been present for the periods of time stated, but indicates rather the total duration of the lesions, many of which undoubtedly were originally benign. A number of the lesions of high grade unquestionably had been of lower grade primarily, but their activity had increased as a result of incomplete treatment or because of irritation. Many of the inactive growths had originated in areas of thickened leucoplakia, keratosis, inflammatory ulcers and traumatic scars, and only recently had become active. Many patients with such lesions had come to the clinic on account of some entirely different conditions, and the lesion of the lip was noted during the course of the general examination. A number of these lesions had not been considered of particular consequence by the patients, and advice concerning them would undoubtedly not have been sought for a considerable time under other circumstances.

ETIOLOGY

The conditions attributed by the patients in this series as causes of the disease were much the same as those usually assigned to epithelioma of the lip. Chronic irritation from smoking and exposure to the elements was outstanding. Exposure to the sun and wind was apparently the most important single irritative factor in the group, but as the majority of patients coming to the clinic are those whose work is largely in the open air, particularly farmers, the significance of this fact is less definite. Traumatic scars and recent trauma were factors in some instances. In others, recurring fissures, leucoplakia, inflammatory ulcers, cheilitis and benign growths of various types had been present on the lip for some time prior to the appearance of the epithelioma. A number of patients ascribed the development of

TABLE II.—DISTRIBUTION OF LESIONS BY GRADE OF MALIGNANCY

Grade	Primary cases		Secondary or recurrent cases	
	Cases	Per cent	Cases	Per cent
1	214	38.77	97	24.87
2	288	52.17	204	52.30
3	47	8.51	74	18.97
4	3	0.54	15	3.85
Total	552		390	

their lesion to a "cold sore" which refused to heal. Many times no probable etiological factors could be elicited, the lesion occurring spontaneously and insidiously. Syphilis did not appear to have any direct bearing, contrary to the condition commonly observed in carcinoma of the tongue.

GRADING

Carcinomata of the lip vary greatly in their degree of activity or grade, ranging from inactive to extremely active types. The majority of them are of moderate activity or of slow growth, most of them being of grade 1 or 2, according to Broders' classification. In this series 311 (33.01 per cent) of the lesions were graded 1; 492 (52.23 per cent) were graded 2; 121 (12.84 per cent) were graded 3, and 18 (1.91 per cent) were graded 4. It will be noted that more than 85 per cent of the lesions belonged to grades 1 and 2, and that a little more than half of them were graded 2.

As a rule, the clinical appearance and the microscopic grading of the lesions correspond very strikingly. However, the presence of acute infection and inflammation often change the clinical picture decidedly, causing the local lesion to develop more rapidly and to metastasize more actively without producing corresponding change in the histological characteristics. Many times growths which previously have remained practically stationary for a time will, as the result of an acute inflammatory process, flare into activity. This fact is apparently not appreciated by members of the medical profession generally, for many of the measures commonly resorted to for the early treatment of carcinoma of the lip are such as to induce inflammatory reaction.

The growths in this series varied from well localized, indurated lesions, confined to a small portion of the lower lip, to large, foul, fungating, ulcerated masses measuring up to 7 or 8 centimeters in diameter, involving not only the entire lower lip and chin, but at times extensively invading one or both cheeks and the upper lip as well. In a number of instances there was attachment to the mandible, and in a few cases extensive invasion of the bone was present. In several instances the growth was extending through the mental foramen and along the inferior dental canal for varying distances. Often, in addition to the primary lesion, there was marked enlargement caused by metastasis to the lymph nodes in the submaxillary, submental, and cervical triangles. In a few instances the malignant lymph nodes were broken down, and the overlying skin was involved.

CLASSIFICATION OF CASES—USE OF TERMS "PRIMARY" AND "SECONDARY" IN THIS PAPER

Because of the difference often noted between the behavior of untreated carcinomata of the lip and those previously treated, the two groups have been studied separately as well as together. For convenience, the cases in which previous treatment had not been carried out are referred to here as primary, and those in which active treatment had been carried out prior to the patients' coming to the clinic as secondary. The primary group contains 552 cases (58.6 per cent), the secondary group, 390 cases (41.4 per cent). Comparison of the activity or grade of the lesions comprising these two groups shows a greater number of lesions of grade 1 in the primary than in the secondary group, approximately the same percentage of lesions of grade 2 (moderately active growths) in both groups, and a higher percentage of lesions of grades 3 and 4 (more active growths) in the secondary group (Table II).

It will be noted that whereas more than 90 per cent of the primary lesions were of low-grade or moderate activity, only 77 per cent of the secondary lesions remained so. Also, whereas approximately 9 per cent of the primary lesions were graded 3 and 4, this percentage was increased to 22 per cent in the secondary growths.

PREVIOUS TREATMENT

The matter of previous treatment is of the utmost importance in a consideration of epithelioma of the lip. The behavior of a previously untreated carcinoma is often quite different from that of one which is recurring following incomplete or inadequate treatment. Use of any agent which tends to produce an acute inflammatory reaction in the growth or in the tissues immediately about it, without completely destroying the lesion is likely to be followed by increased activity, with greater likelihood of metastasis. This agent may be accidental trauma, acute infection, undue exposure to the elements, especially actinic rays, or any radical therapeutic measures such as

irradiation, excision, electrocoagulation, the actual cautery, or escharotics.

All therapeutic agents are not equally prone to induce stimulation following inadequate application. It has repeatedly been observed at the clinic that increased activity of epitheliomata of the lip frequently follows inadequate treatment by radium and roentgen-rays, and that such recurrences are particularly difficult to control. The same observation also has been made relative to malignant growths of other portions of the mouth and face. Many of the patients in this series previously had received repeated irradiation. In fact irradiation had been the most common method of treatment used in these secondary cases prior to examination of the patients at the clinic. In 157 (40.2 per cent) of the 390 secondary cases in the series the patients had received either treatment with radium or roentgen-rays, or both, previously. Sixty-three (40.12 per cent) of these 157 had received other treatment as well, but the irradiation comprised the major portion of the treatment. In 139 cases (35.6 per cent) the patients had received applications of caustic substances or escharotic pastes. In 27 cases (6.9 per cent), treatment had been by the actual cautery or electrocoagulation, whereas in 67 cases (17.1 per cent), the lesion had been excised with either the scalpel or the cutting cautery. The high percentage of recurrences following previous irradiation and previous use of escharotic pastes is noteworthy. This may indicate more general use of these measures for treatment of carcinoma of the lip, lack of experience of the therapeutist consulted, or a lower degree of efficiency of these agents as compared with other therapeutic measures.

As would be anticipated, extension to lymphatic structures was encountered much more commonly in the secondary cases than in the primary cases. In the primary group of 552 cases involvement of lymphatic structures was found in 25 (4.5 per cent), whereas in the secondary group of 390 cases metastasis was present in 66 (17 per cent). It is interesting to note that metastasis had not occurred in a single case of the primary lesions of grade 1, whereas such extension had taken place in 4 cases in which lesions of grade 1 were present, and in which treatment had been carried out previously. The fact that only 14 primary lesions of grade 2 metastasized, as compared with 29 of the secondary lesions of grade 2 is likewise noteworthy.

TREATMENT

The treatment of suspicious lesions of the lip carried out as a routine in the clinic was excision, either by removing a superficial elliptical portion, or a wedge, wide of the lesion. If the lesion on the lip appeared clinically to be malignant, a V-shaped incision was made, the width of the excised portion depending on the size and apparent activity of the lesion. The tissue removed always was subjected to microscopic examination. If on examination it was proved to be benign, further treatment was not required. If, however, on histological study the growth was found to be of a sufficiently high grade of malignancy that there was likelihood of metastasis, dissection of the lymphatic structures in the submental and submaxillary triangles on both sides was carried out, unless contra-indicated because of the patient's advanced age or poor general condition. If the lesion was graded 1, its clinical appearance, together with the matter of previous treatment, was taken into consideration in determining the type of treatment advisable for the lymphatic structures. Sometimes, depending on the extent of the carcinoma, it was necessary to perform a plastic procedure at one or both angles of the mouth in order to reconstruct the lower lip. This was usually done by lateral incision through the angle of the mouth into the cheek, and removal of a wedge above in order to equalize the length of the upper lip. In this manner it is possible to rebuild the entire lower lip in one stage immediately following its removal for an extensive carcinoma, or as a result of trauma. Immediate reconstruction is advisable only in case there is no attachment to the mandible, and the growth can be removed with a wide margin of normal tissue. When the tumor was attached to the mandible or was very active and extensive, it was either destroyed widely with electrocoagulation or was excised with the cutting cautery. The mandible was thoroughly cauterized at the site of attachment, and the wound was left wide open except for suturing together the skin and mucous membrane at the margins laterally. Reconstruction of the lost tissues was delayed for from 6 months to a year, depending on the extent and activity of the growth. In several cases of the group in which there was involvement about the chin, and direct extension through the mental foramen and along the inferior dental canal, cure was effected by carrying out thorough cauterization after the outer bony wall of the canal was removed, with dissection of nodes subsequently. Of the 942 cases in which operation was performed, simple excision was carried out in 760 (80.67 per cent). Excision and immediate plastic closure was done in 120 (12.7 per cent) of the cases, and cautery excision or diathermy was necessitated

by the extent and activity of the growth in 62 (6.58 per cent).

At times a clinically definite epithelioma of the lower lip was encountered, together with thickening extending laterally along the vermilion border on either side. The thickened lesion, although not malignant at the time of examination, was potentially so, and its removal was desirable. For this purpose the thickened regions were superficially excised and the wounds immediately closed, with the clippings left attached mesially. The incision was then continued as a V, in order to remove the main portion of the growth. The sides of the V were curved outward somewhat, so that on closing the wound the vertical dimension of the lip was not shortened. These regions of thickening included leucoplakia, keratosis, traumatic scars, recurring fissures, inflammatory ulcers, and cheilitis. Such regions unquestionably account for many of the so called local recurrences that have been noted following treatment of carcinoma of the lower lip. These "local recurrences" are often entirely new-growths which have developed in areas of thickening that were present at the time of the original operation, but which were not accorded adequate consideration. I am convinced that some of the local recurrences mentioned by Sistrunk, in his report of a series of epitheliomata of the lower lip from The Mayo Clinic a few years ago, were in reality new lesions developing on areas of thickening of this type.

In order to effect a cure in cases of epithelioma of the lip, it is necessary not only to remove the local growth but to prevent metastasis by blocking the lymphatic channels as well. This is most effectively done by the removal of these structures surgically. Fortunately, the anatomical situation and distribution of the lymphatic channels draining the lower lip permit of their complete surgical removal.

The present-day treatment of the lymphatic structures in carcinoma of the lower lip is based on the work of Dorendorf, published in 1900. By injecting a suspension of Prussian blue in a mixture of ether and turpentine, he demonstrated that the lymph vessels of the lower lip regularly enter the submental and submaxillary nodes, but that some of them may drain directly into the deep cervical group of the same or the opposite side of the neck, and a few may enter the mental foramen of the mandible. Because of the fact that the lymph vessels regularly enter the submental and submaxillary nodes, dissection of these triangles is now carried out as a routine in most surgical clinics for the treatment of carcinoma of the lip. In the majority of cases metastasis takes place to these groups primarily, if at all, and their removal effectively blocks extension of the disease through the lymph channels, provided the operation is carried out before these nodes have become involved. Extension of the malignant process through the lymph vessels draining directly into the deep cervical nodes or those entering the mental foramen rarely occurs, so that removal of the cervical nodes along with the submental and submaxillary groups is scarcely justifiable as a routine procedure. The impracticability of removing those entering the mental foramen is quite obvious. These small, frequently overlooked groups of lymph vessels do, however, account for the unusual situation of secondary deposits at times encountered in cases of epithelioma of the lip. Extension along these channels practically never occurs except in the case of recurring lesions, and those that have been activated by inadequate treatment.

Removal of the submental and submaxillary lymphatic structures and of the submaxillary salivary gland on either side was carried out as a routine in the treatment of the epitheliomata of the lower lip in the cases reported in this series unless definitely contra-indicated. If involvement of any of these groups of lymphatic structures was found, dissection of the anterior triangle or block dissection of that side of the neck was done, with or without removal of the sternomastoid muscle, depending on the activity of the lesion and the extent of involvement. The procedure was carried out with the patient under either general or paraspinal block anæsthesia. As a rule, a general anæsthetic was preferable, as in some cases anæsthesia was not complete when local anæsthesia was used, and sensation at times returned before the operation was finished. In general, intratracheal anæsthesia, with nitrous oxide, carbon dioxide, and ether, is now being used with entire satisfaction.

Dissection was usually done with the knife, although in a few cases in the series dissection by cautery was carried out. With the cautery point heated to redness, capillary oozing was well controlled, yet there was not sufficient charring to interfere with primary healing. The chief advantage of dissection by cautery was the decreased tendency to engrafting of malignant cells. The results in the small group of cases in the series operated on in this manner were not such as to indicate that the method possessed outstanding superiority over dissection with the knife. It must be borne in mind, however, that only in cases in which the malignant process was more

advanced, and obvious extension to lymphatic structures was present was excision by cautery used. In a few instances it was felt that considerably more inflammatory reaction followed the operation than would have resulted following dissection with the knife, of the same extent.

Lymph nodes are dissected out much more frequently as a prophylactic measure than because they are involved in the malignant process. The operation was performed on 549 of the 942 patients included in the series. In only 91 (16.53 per cent) of these 549 were the nodes involved, the nodes in the remaining 458 cases (83.42 per cent) being free from involvement. Irrespective of the size and activity of the local lesion, the most satisfactory end-results are to be anticipated in this group in which no involvement of the nodes was demonstrable at the time of their removal. Incidentally, this group is composed of a higher percentage of primary cases, whereas, the group in which there is involvement of lymph nodes contains a correspondingly greater number of secondary or recurring cases.

Metastasis into the mental node occurred in only 5 (0.5 per cent) of the 942 surgical cases. In my experience, involvement of the mental node on one or both sides has occurred only in previously treated cases. The possibility of metastasis into these lymph nodes from carcinoma of the lower lip is mentioned by few writers. From this situation prompt extension through the mental foramen into the inferior dental canal is to be anticipated. In all 5 of the cases mentioned here lesions had recurred. Three of the lesions had been treated previously with radium, one had been removed with escharotic paste, and one had been treated with repeated subcutaneous injections of a nostrum for cancer. These injections were made immediately about the periphery of the local growth, and caused marked acute inflammatory reaction. Four of the lesions were graded 2, the fifth was graded 3. The submental and submaxillary lymph nodes had been dissected as a routine in all of these cases at the time these patients were first treated in the clinic. Involved nodes were found in 2 and a block dissection was accordingly done on the same side of the neck. In addition, 3 of the patients received irradiation over the neck and lower portion of the face. The patients returned 3, 3½, 4, and 11 months later, with involvement of a mental node. In the case in which the interval of 11 months had elapsed, involvement of the mental node was advanced and fixation was present. Treatment in 4 of these cases consisted of excision of the involved node through the buccal fold inside the mouth, and subsequent cauterization of the wound. In 1 case, because of attachment of the node to the overlying skin, cauterization of the entire area from the outside, destroying all of the soft tissues overlying the mandible in this area, was carried out.

The deep cervical nodes later became involved in a few cases in which involvement of the submental and submaxillary nodes had not been demonstrable at the time of their removal. This does not, however, justify the conclusion that extension had occurred directly into these nodes, since, as serial sections were not made, involvement of the nodes previously removed might readily have been overlooked.

Irradiation was used to supplement surgery in the treatment of the lymphatic structures in a little more than half (500) of the cases in the series. Approximately half (245) of these patients received radium therapy during the interval between excision of the lesion of the lip and dissection of the lymph nodes. The remainder (255) were given treatment by radium or roentgen-rays following removal of the nodes. All of the radium treatment was given with distance and screening; the screening consisted of 2 millimeters of lead together with the brass capsule containing the radium, and a block of wood 2.5 centimeters thick was used to secure distance. An average of 5000 milligram hours was applied over the submaxillary and submental regions unless there was definite clinical evidence of involvement of lymphatic structures, in which case additional treatment was extended over the cervical regions. The patients in this group, involvement of whose lymphatic structures was demonstrated microscopically following excision, received further irradiation subsequently, usually in the form of roentgen therapy.

In a group of 287 cases, dissection of the lymph nodes was not carried out. Most of these were patients of advanced years, or in poor general condition, or those whose lesion of the lip was of low grade. A few were patients for whom dissection of lymph nodes was advised but was refused. In none of the cases was there definite clinical evidence of metastasis. In all of the cases the local lesion only was excised, the regional lymphatic structures either being left entirely alone or irradiated. Metastasis into the lymph nodes of the neck did not develop subsequently in any of the cases in which irradiation was not carried out, and in only 2.9 per cent of cases in which irradiation was applied. This is a much lower percentage than was noted by Sistrunk in a similar group a few years ago. However, the group under consideration here does not form a

fair cross section of cases of carcinoma of the lip, since in 97.55 per cent of the cases in which irradiation was not given the lesions were of grades 1 and 2, whereas in 90.6 per cent of cases in which irradiation was applied the lesions were of the same low grades of malignancy. Moreover, 59.75 per cent of the former group and 43.78 per cent of the latter group were lesions of grade 1, which very rarely metastasize. In addition, many of the patients were older than 70, and the likelihood of metastasis, especially of such comparatively inactive growths, was still less on that account.

In cases of epithelioma of the lip, in which operation was not considered because of the extent of the growth or because of the advanced age or poor general condition of the patient, treatment was entirely by means of irradiation. In most of these, treatment was looked on as a palliative measure.

SELECTION OF CASES FOR TREATMENT

The prognosis in epithelioma of the lower lip in which there is metastasis to the cervical nodes is entirely different than when the nodes are not involved. Comparison of the results obtained by different surgeons in the treatment of this group of cases is difficult because opinions will vary greatly concerning what constitutes an operable case. Whereas one surgeon may refuse to operate when more than one group of nodes is enlarged, another will perform a radical operation even when there is fixation of a cervical mass. Obviously, if more advanced cases are included in a given series, the percentage of cures will be lower. This accounts for the marked difference in results obtained in groups of cases reported from the same institution at different times. Simmons and Daland, reviewing cases of this type in which treatment was instituted at the Massachusetts General Hospital between January 1, 1909 and January 1, 1919, found 28 per cent of 3 year cures, whereas Shedden, when studying a similar group from the same institution from January 1, 1919, to January 1, 1923, noted 57 per cent of 3 year cures. The same is true in similar groups from other institutions. Sistrunk, reporting cases of this type in which operation had been performed at The Mayo Clinic during 1912, 1913, and 1914, found only 18.1 per cent of 5 to 8 year cures, whereas in the present series there is a percentage of 39.13 cures. As a matter of fact, as pointed out subsequently, in a number of the cases in the present series, the local lesion was so far advanced, as was also metastasis to cervical nodes, that the patients might justifiably have been refused operation.

Simmons and Daland pointed out the obvious but not fully appreciated facts that the presence of palpable lymph nodes does not necessarily mean that metastasis has occurred, and the converse is also true. In fact, in Shedden's series the nodes were palpable in 68 per cent of the cases before operation, but of these, carcinoma was present in only a fifth, whereas in 32 per cent the nodes were not palpable, yet carcinoma was present in 10 per cent of them. These facts disclose the utter impossibility of comparing a group of cases in which epithelioma of the lip and palpable lymph nodes are present, and in which treatment is by means of irradiation, escharotic pastes or any other non-operative procedure, with a similar group of cases in which there was microscopically proved metastasis, and in which treatment has been surgical.

The outstanding contra-indications to dissection of lymph nodes of patients with carcinoma of the lower lip are advanced age, poor general physical condition, and too extensive involvement. Metastasis is less likely to occur among patients of advanced years than among younger patients, because of changes in the lymphatic vessels and lessened activity of the lymphatic circulation. On this account dissection of lymph nodes is, as a rule, not advised for patients more than 70 years of age, unless the patient's general condition is exceptionally good, and the lesion of the lip active. The mortality and morbidity from dissection of lymph nodes is very low, and the patient's general physical condition rarely justifies withholding the procedure in cases in which it is otherwise indicated. Extensive involvement is the most common contra-indication to surgical removal of the lymphatic structures. When clinically obvious metastasis extends to the base of the neck or beyond this, palliation only is likely to result following any type of treatment. The same is true when a metastatic mass in the neck is fixed to the mandible or attached to the carotid vessels, unless the lesion is of a low grade of malignancy. Often, it is impossible to determine the operability of a cervical mass without surgical exploration. Sometimes a tumor that, on clinical examination, appeared to be invading the jaw will be found at operation to involve the periosteum only, and may be stripped off readily. Cauterization of the bony surface then affords a reasonable chance of controlling the disease in this region. If the lesion on the lip is highly malignant, and more than one cervical node is involved, many surgeons feel that dissection of lymphatic structures, however extensive, adds little to the prognosis. Some among them, in fact, have taken the

TABLE III.—RESULTS OF EXCISION OF LABIAL LESIONS OF VARYING EXTENT*

Operation	(1)	(2) Traced		(3) Lived 3 years or more		(4) Lived 5 years or more		(5) Lived 10 years or more	
	Total patients	Patients	Per cent	Patients	Per cent	Patients	Per cent	Patients	Per cent
Simple excision	581	469	81	414	88.27	295	84.28	25	62.50
Excision and immediate plastic reconstruction	102	85	85	64	75.30	43	65.15	4	33.33
Excision by cautery or diathermy (delayed plastic reconstruction)	48	41	85.41	16	39.03	8	27.58		

*The percentages in column (2) are related to the quantities in column (1); that is, 469 is 81 per cent of 581, and so forth. However, the percentages in columns (3), (4), and (5) are not related to any other quantity expressed in the table. The significance of percentages in these columns can be perceived from an example, as follows: 414 is 88.27 per cent of that number of patients who underwent simple excision 3 or more years before the time of the study, and so forth.

TABLE IV.—END RESULTS*

	Patients		Lived 3 years or more		Lived 5 years or more		Lived 10 years or more	
	Total	Traced	Patients	Per cent	Patients	Per cent	Patients	Per cent
Primary	425	363	319	87.88	217	80.37	16	42.1
Secondary	301	267	211	79.02	140	68.29	15	36.58

*See footnote to Table III.

TABLE V.—DISSECTION OF LYMPH NODES WITHOUT INVOLVEMENT OF LYMPHATIC STRUCTURES*

	Patients	Per cent
Total	359	
Traced	308	85.79
Lived 3 years or more	283	91.88
Lived 5 years or more	210	89.71

*See footnote to Table III.

stand that surgical removal of the lymphatic structures is futile when there is definite clinical evidence of involvement.

MORTALITY FOLLOWING TREATMENT

The risk associated with the surgical removal of carcinoma of the lip is very slight. Even in extensive lesions in which marked dental infection is present among patients of advanced years, primary healing almost invariably occurs and complications of any sort are extremely unusual. It is rare that either the patient's age or general physical condition serves as a contra-indication to operation. Although dissection of lymph nodes is not as a rule carried out if patients are more than 70 years of age, there was no operative mortality among patients more than this age who underwent this procedure. In spite of the extent of the dissection required when the lymphatic structures are involved, the risk of operation is very low. Among the 942 cases in the series in which operation was performed, there were four postoperative deaths, a mortality of 0.42 per cent. Three of the patients were known to be very poor surgical risks. One of the 3, a man aged 75 years, died of bronchopneumonia 17 days after excision of an extensive epithelioma of the lip and immediate plastic reconstruction under local anæsthesia. Another of the 3, a man aged 65 years, died of myocardial insufficiency 3 days after removal of a lesion from the lip. At present, both of these patients would probably be treated by irradiation. The third patient, a man aged 62 years, died of lobar pneumonia 11 days after excision of the nodes and the growth on the lip at a single operation, this being the only death attributable to operation associated with removal of the lymphatic structures in 549 cases, a mortality of 0.18 per cent. The fourth patient, a man aged 43 years, died of erysipelas 3 weeks after excision of an extensive carcinoma of the lip, with immediate plastic reconstruction.

RESULTS

Not only was extension to lymph nodes found in a much higher percentage of cases in the secondary group at the time of the original operation at the clinic, but later, more of the patients in this group had recurrences either locally or in the lymph nodes. In only 13 (2.36 per cent) of the cases in the primary group did such lesions recur subsequently, as compared with 41 (10.51 per cent) in the group of secondary cases. Moreover, 17 patients (3 per cent) of the primary group died from the carcinoma of the lip, whereas 55 patients (14.1 per cent) of the secondary group died.

Since the method of surgical removal of the local lesion in cases of carcinoma of the lip depends largely on the extent of the growth, its activity and previous treatment, the end-results likewise will vary with the type of procedure carried out (Table III). The cases in this series in which simple V-shaped excision of the local growth was done consisted of cases in which the lesions ranged to 2.5 centimeters in diameter. As would be expected, the end-results in this group are more satisfactory than in those requir-

TABLE VI.—RESULTS OF EXCISION IN CASES IN WHICH LYMPH NODES WERE INVOLVED

	Patients	Per cent
Total	91	
Number heard from	85	94.9
Lived 3 years or more	31	49.2
Lived 5 years or more	18	39.13*
Lived 10 years or more	3	23.67*

*See footnote to Table III.

ing immediate or delayed plastic reconstruction, since the group includes earlier growths and a higher percentage of lesions of low grade. In many of the cases in which delayed reconstruction was necessary, growths involved the entire lower lip, and at times one or both cheeks, and the upper lip as well. In addition, fixation to and involvement of the mandible was present at times.

The end-results in the secondary cases, as compared with those in which the lesion of the lip had not been treated previously (primary cases) are noteworthy. These are shown in Table IV.

A review of the statistics pertaining to the cases in which the nodes were not involved reveals that 91.88 per cent of the patients lived for 3 years or more, and 89.74 per cent lived for 5 years or more following operation (Table V).

Of the 25 patients who died less than 3 years after operation, only 11 (44 per cent) died from recurrence of the malignant process. Eleven of the patients in the group are known to have died of causes other than epithelioma of the lip or nodes, whereas in 3 cases (12 per cent) the cause of death was indeterminate (Table VI).

The average length of life of patients with involvement of submental or submaxillary nodes who died within 3 years was 18.96 months, and for those with involvement of the cervical nodes, 12 months. Nine patients of this group treated during 1928 and 1929 were still living when last heard from, in 1931.

One of the principal reasons for undertaking this study was to determine the value of irradiation used to supplement surgery in these cases, and whether irradiation used before operation was more effective than when used after removal of the nodes. The results are shown in Table VII.

These groups are made up of consecutive cases, including both primary and recurrent lesions. It will be noted that whereas in the group treated with surgery alone, practically 83 per cent of the patients were well for at least 3 years and 79 per cent for 5 years or more; in the group in which irradiation supplemented surgical measures 85 per

TABLE VII.—METHODS OF TREATMENT*

	Patients	Per cent
I. Surgery without radiation		
Total cases	228	
Traced	194	86.22
Lived 3 years or more	161	82.99
Lived 5 years or more	100	78.74
II. Surgery with postoperative radiation (radium or roentgen rays)		
Total cases	500	
Traced	441	88.37
Lived 3 years or more	376	85.26
Lived 5 years or more	269	80.54
III. Surgery with pre-operative radiation and postoperative radiation, if lymph nodes involved		
Total cases	245	
Traced	213	86.94
Lived 3 years or more	187	87.79
Lived 5 years or more	136	83.95

*See footnote to Table III.

cent of the patients were well for 3 years or more, and 80.5 per cent for 5 years or more. The difference of approximately 2 per cent in the 3 year group and of 1.5 per cent in the 5 year group seems surprisingly small, although irradiation would naturally be used in a higher percentage of the less favorable group. The group in which radium treatment was used prior to dissection of lymph nodes reveals some further improvement in the results, however, there being practically 88 per cent of 3 year cures and 84 per cent of 5 year cures. This latter group thus reveals a 5 per cent advantage over the purely surgical group, both as regards the 3 and the 5 year cures.

In the following group of 287 cases (Table VIII) the local lesion was excised, but the nodes were not removed either because of the inactive nature of the growth, or because of the advanced age or poor general condition of the patient. In 192 of these cases, radiation therapy was given over the regional lymphatic structures, whereas in the remaining 95 cases the lymphatic structures received no treatment.

Three of the patients are living from 3 to 5 years after removal of an involved mental node. The two who are dead lived for 2½ and 3 years, respectively, following the operation.

The group in which treatment was entirely by means of irradiation included 31 patients, all of whom received either roentgen therapy or radium, with distance and screening over the regional lymphatic structures, and radium on an applicator or as an unscreened plaque to the lesion of

the lip, except for a few cases in which seeds or needles were implanted into the local lesion. The ages of the patients ranged from 42 to 89 years. Most of them were of advanced years, the average age being a fraction over 75 years. One patient of the group could not be traced. Of the 30 traced, 29 (96.6 per cent) are dead. One is living and free from recurrence 6½ years from the time treatment was applied. This patient was 86 years of age at the time he came to the clinic, with an epithelioma 2.5 centimeters in diameter on the lower lip. Of the 29 patients who are dead, death in all probability was due to carcinoma of the lip or lymph nodes in 22 (75.8 per cent). In 7 (24.1 per cent) cases death resulted from other causes. These 7 patients were known to be free from recurrence for from 2 to 5½ years following treatment. The average length of life of the patients who died of epithelioma was a little more than 2 years (26 months).

The effectiveness of surgery supplemented with radiation in controlling the malignant process in some of the cases in which involvement was extensive is evident from the 3 reports of cases which follow.

CASE 1. A man, aged 37 years, came to the clinic November 3, 1924, with an extensive, recurring epithelioma of the lower lip that had been treated with an escharotic ointment a year previously. The growth involved three-fourths of the lower lip, and appeared very active clinically. An obviously malignant node 2 centimeters in diameter was present in the submental region. The lesion of the lip was excised with a wide V shaped incision and plastic reconstruction was made at each angle of the mouth to reconstruct the lip. Microscopically, the lesion proved to be a squamous cell epithelioma of grade 3. Eleven days later complete bilateral dissection of the anterior cervical triangle was made. In addition to the malignant submental node, moderately advanced involvement of the deep cervical lymph nodes and submaxillary nodes on the right was found. The surgical note stated that involvement was extensive and the prognosis poor. About a year later the patient returned with a fixed, malignant node 2.5 centimeters in diameter opposite the mental foramen on the left side. This was destroyed with diathermy. The patient has now been well for more than 7 years.

CASE 2. A man, aged 65 years, came to the clinic June 15, 1925, because of an extensive epithelioma that involved the full thickness of the lower lip and extended approximately 5 centimeters lateral to the left angle of the mouth. The lesion previously had been irradiated twenty times, and there was fixation of the growth to the left side of the mandible anteriorly. Several enlarged nodes were present in the left submaxillary region, the largest measuring 2 centimeters in diameter. The primary growth was excised widely by cautery June 16, 1925, and the mandible at the area of fixation was thoroughly cauterized. Microscopically, the growth was a squamous cell epithelioma of grade 3. At the same time radium emanation points were inserted into the large node in the submaxillary region. Following this the patient was given approximately 6000 milligram hours of radium over the neck and left cheek. Approximately 3 months later, bilateral submental and submaxillary nodes were dissected, with a block dissection on the left. Extensive malignant involvement of the left submental and submaxillary nodes and the left submaxillary salivary node was found. The surgical note at the time of operation stated that the prognosis was very poor. Roentgen treatment was given over the neck prior to dismissal. The patient was living and well when last heard from 5 years and 4 months after the dissection.

TABLE VIII.—EXCISION OF EPITHELIOMA OF LIP: RESULTS IN RELATION TO IRRADIATION AND RESECTION*

	Total patients	Patients traced	Lesions graded 1 and 2, per cent	Lived 3 years or more		Lived 5 years or more	
				Patients	Per cent	Patients	Per cent
Without dissection or irradiation of lymph nodes	95	82	97.55	68	82.9	31	75.69
Without dissection of lymph nodes but with irradiation	192	169	90.6	140	82.8	96	73.28

*See footnote to Table III.

CASE 3. A man, aged 47 years, came to the clinic August 15, 1928, with an extensive, very active appearing epithelioma involving almost the entire lower lip well down into the labial fold. The lymph nodes on both sides of the neck were greatly enlarged, and clinically appeared to be involved. The lesion of the lip was excised widely with cautery August 16, 1928, and microscopically proved to be a squamous cell epithelioma graded 3. The following day bilateral submental and submaxillary dissection of lymph nodes with block dissection on the left side was done. The nodes were involved in the left submaxillary and upper deep cervical regions. One of these nodes had broken down, and liquefied carcinoma escaped into the wound. The surgeon's note at the time of operation stated that the patient's condition seemed hopeless. Roentgen treatment was given subsequently. The patient was living and well when last heard from, 2 years and 2 months later.

DIOTHANE IN SURGERY OF THE ANAL CANAL[1]

A Clinical Survey of One Hundred Cases

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IN our experience, a modified low spinal anæsthesia has proved an entirely safe and eminently satisfactory procedure for anorectal operations, its presenting advantages being early and uniform action together with a complete sphincteric relaxation which permits non-traumatic visualization of the field (8). Nor have we been convinced that any of the chemical combinations suggested are safer or more effective than procaine crystal subarachnoid anæsthesia.

Unfortunately, perfect surgical anæsthesia is too often quickly followed by a distressing period of sphincter spasm, pain, and inability to void which provides the patient with reminiscent material for the years to come. This reaction is at present modified by hot applications, hot sitz baths, and analgesics given orally but no proctologist can be so complacent in the premises as to deny interest in any device which offers to prolong the period of local insensibility and possibly eliminate this stage of acute sphincter hypertonicity.

Previous reports on the pharmacology and clinical action of diothane, the new di-phenylurethane derivative, suggest that its toxicity is near that of procaine, that it is slowly absorbed after tissue infiltration with a consequent prolongation of anæsthesia (5, 6, 7) and that favorable results have been obtained in urologic (1, 4), ophthalmologic (3) and nose and throat procedures (9) where this chemical has been used as an anæsthetic agent by infiltration and topical application.

The present report summarizes a 4 months' experience in which the agent was injected in anal and perianal tissues in one hundred instances, the lesions present being hæmorrhoids (50 cases), fissures (40 cases), together with 10 instances of miscellaneous minor lesions. We regard local infiltrations of fistulæ as unsafe.

Diothane is apparently chemically incompatible with spinal fluid, it has not been tried as an intrasacral injection. Except in rare instances it would appear unwise to produce prolonged and complete sacral plexus paralysis. Final conclusions are not here offered as to the topical efficacy of the agent in the anal canal—our brief experience permits the tentative suggestion, however, that cocaine is not sufficiently toxic in the very small amounts necessary to anæsthetize painful anal lesions to counterbalance what appeared to be its greater and more immediate effectiveness.

All patients were given small preliminary doses of some barbiturate as animal experiments have indicated that this drug has a similar protective action preceding diothane to that discovered in connection with cocaine and procaine (7). No greater amount than 1 ounce of the anæsthetic was used in any one case, and in the majority a dilution of ½ of 1 per cent was found to be optimum, except where a few cubic centimeters of 1 per cent was used in marginal lesions.

HÆMORRHOIDS

Twelve cases of thrombotic external piles and integumentary marginal tags were operated upon as office patients after infiltration of approximately 2 cubic centimeters of 1 per cent diothane in each case. It was immediately found that the injection was associated with a sharp burning pain definitely greater than the discomfort of procaine injection. The pain was momentary, however, and after a 5 minute period anæsthesia was perfect in each instance. The period of anæsthesia varied from 6 hours in one case to 4 days in another; the majority of the patients stated that sensation returned so slowly, after a period of several days, that they were unable to determine the dividing line. Postoperative swelling was not marked and was permanent in none of this group.

A more varied experience is recorded in connection with internal piles. Thirty-eight patients were operated upon under diothane infiltration alone or diothane infiltration locally as an adjunct to a low subarachnoid anæsthesia. The latter was found preferable from the standpoint of operative relaxation.

As controls, a series of 30 unselected and consecutive cases in which patients were operated upon under spinal anæsthesia alone was compared with the first 30 hæmorrhoids in which diothane was used. Table I presents a summary of the two series. All hæmorrhoids were removed by a ligature and excision procedure. It will be noted that the type of spinal anæsthesia used (35 milligrams of procaine in 10 minims of spinal fluid) affords a period of local insensibility of from 1 to 2 hours, the usual period being 1 hour and 25 minutes. Where diothane was injected, such uniformity was

[1]From the Section on Proctology, Baylor University School of Medicine. Read before the Texas Surgical Society, Dallas, February 1934.

TABLE I.—SUMMARY

A. Hæmorrhoidectomy; Diothane Infiltration

Case	Additional anæsthesia	Duration anæsthesia hours #	Morphine*	Codeine*	Catheter*	Complication
1	Spinal	16	1	0	0	0
2	Spinal	5	0	1	0	0
3	Spinal	24	0	0	0	Tags
4	Spinal	7	1	1	2	Tags
5	Spinal	1	2	3	2	0
6	0	72	0	0	0	Tag
7	0	8	0	1	0	0
8	Spinal	1½	0	1	1	0
9	Spinal	8	0	1	0	0
10	Spinal	12	0	1	0	0
11	Spinal	14	1	1	0	0
12	Spinal	7	0	2	0	0
13	0	48	0	0	0	0
14	Spinal	7	0	1	0	0
15	Spinal	1½	2	1	2	0
16	Spinal	72	0	0	0	0
17	Spinal	2	2	2	2	0
18	Spinal	72	0	0	0	0
19	Spinal	12	0	1	2	0
20	Spinal	12	0	1	0	0
21	Spinal	12	1	2	0	0
22	0	8	0	1	0	0
23	Spinal	2	0	1	0	0
24	Spinal	7	2	0	0	Superficial infection
25	0	72	0	0	0	0
26	Spinal	2	0	2	1	Abscess
27	Spinal	3	2	1	1	Tag
28	Spinal	9	0	2	0	0
29	Spinal	3	0	2	0	Tags
30	Spinal	2	1	1	0	Superficial infection

Summary.....30 Spinal.....25 Diathone alone.....5

Morphine 0 20(66.6%) Morphine 1 5(16.6%) Morphine 2 5(16.6%)

Catheter.....0 22(73.3%) Catheter.....1 3(10.0%) Catheter.....2 5(16.6%)

Tags.....5 Infection.....3 8 (26.0%)

#i.e. First narcotic.
*First 24 hours.

B. Hæmorrhoidectomy; Spinal Anæsthesia Alone

Average duration anæsthesia; 1 hour 25 minutes.

Morphine first 24 hours:

Morphine.....0
Morphine.....1 6 (20.0%)
Morphine.....2 11 (36.6%)
Morphine.....3 9 (30.0%)
Morphine.....4 4 (13.3%)

Catheter first 24 hours:

Catheter....0 11 (36.6%)
Catheter....1 11 (36.6%)
Catheter....2 7 (23.3%)
Catheter....3 1 (3.3%)

Complications:

Stricture.....1
Fissure.....1
Infection.....3
Tags.....1
Total.....6 (20.0%)

absent. In 7 instances the return of sensation was in less than 2 hours, and as these 7 required morphine or were catheterized or both, it was believed that the drug was for some technical reason ineffective in this group. In the remainder, the period of anæsthesia was prolonged for several hours to several days and the amount of discomfort and spasm during the first 24 hours as measured by morphine administration and catheterization was definitely decreased.

TABLE II

A. Fissurectomy

Duration of anæsthesia:*

2 to 6 hours	5
6 to 12 hours	6
18 to 48 hours	4
72+ hours	10
	25

Diothane infiltration

Morphine first 24 hours (25 cases)—

	Cases	Per cent
0	22	88
+	3	12

Catheterization

0	22	88
+	3	12

B. Fissurectomy — Without diothane

Average duration anæsthesia* (25 consecutive cases) 1 hour 26 min.

Morphine first 24 hours:

	Cases	Per cent
0	1	4
+	24	96

Catheterization:

	Cases	Per cent
0	15	60
+	10	40

*Estimated from the time narcotic first necessary.

Several methods of infiltration were tried, among them direct injection of the solution in the bases of the hæmorrhoids and lateral block of the sensory branches of the inferior hæmorrhoidal nerves. The first technique produced distortion of the field, immediate leakage of the solution when the pile was removed, and, we concluded, a decreased period of anæsthesia. We were convinced that the second method is preferable, although injection of the drug under all operative wounds as a final step gave fair results.

We were quite interested in an estimation of the local complications which might result from the injection of this new chemical in the perianal tissues and the after-course was closely observed. It will be noted that 6 (20 per cent) of the cases without diothane presented a minor complication during the healing period as compared with 8 (26 per cent) in the diothane series. Tag formation requiring subsequent removal was the predominant complication where diothane had been injected and from observation of the postoperative course of the entire group we came to the conclusion that this marginal swelling will occur in a moderate percentage of those in which the chemical is injected. The local abscesses which occurred were apparently chemical in nature. Further experience convinced us that the use of an isotonic solution would control this complication to a large extent.

FISSURE

The value of the anæsthetic was more clearly demonstrated here.

A similar comparison was made of two series of patients treated for anal ulcer by radical operation, the first under gas, spinal, or procaine infiltration and the second under diothane infiltration alone (18 cases) or combined with other anæsthetics. As will be seen from the summary in Table II, by diothane injection the period of anæsthesia was prolonged from several hours to several days, practically no morphine was required and catheterization was decreased from an incidence of 40 per cent to 12 per cent. No complications of note were seen in either series except that in 1 diothane case a marginal abscess developed.

Since A. B. Graham suggested the local injection of 5 per cent quinine urea hydrochloride in the palliation or cure of early anal fissure (2) this procedure has obviated radical fissurectomy in many small, non-infected anal ulcers. The only objection to the quinine solution is the extreme pain connected with its introduction and a definite limitation of amount to avoid slough. Fifteen fissures of this description have been treated by injection of 1 cubic centimeter of 1 per cent diothane behind and lateral to the ulcer. The results, together with those of a control series of quinine urea hydrochloride injections are set forth below:

	1 per cent diothane 15 minims	5 per cent quinine urea hydrochloride 10 minims
No improvement	1	3
Healed, recurred at once	3	2
Remained healed to date	11	10
	15	15

It is seen that there is no special choice between the two agents from the standpoint of effect. Diothane is somewhat less painful in administration.

Twelve minor cases, condylomata, fissures, crypts and sinuses, were operated upon as outpatients in the rectal clinic of the medical school under the direction of Dr. H. G. Williams, then resident surgeon. Small amounts (usually 15 c.cm.) of one-half per cent diothane were used. Barbiturates were administered before operation, the patient was observed for an hour after the procedure and sent home with several capsules containing codeine. In practically all instances the capsules were returned by the patient on his reappearance in 48 hours, with the statement they had been unnecessary; in no instance was the patient incapacitated by discomfort or unable to void. The usual length of anæsthesia was 48 to 72 hours. Because our usual "clinic" patient is quick to complain after any operative procedure we feel that these results were unusually significant.

CONCLUSIONS

From the absence of any constitutional reaction or complication in the entire group of 100 cases we are convinced of the relative lack of toxicity of the chemical under proper clinical precautions.

The postponement of pain and spasm, especially after fissure operations and in the majority of the hæmorrhoid group, is highly suggestive of

the possible value of this new anæsthetic agent in the special field investigated. No doubt further experience will establish a technique offering more uniform results. Lateral nerve block in hæmorrhoidectomies or infiltration under all operative wounds as the last step of a procedure performed under a low spinal anæsthesia were each satisfactory.

The chief objections noted are pain when the drug is introduced without previous anæsthesia, an increased tendency to "tag" formation after hæmorrhoidectomy, and the occasional development of local abscess, apparently chemical in nature.

Diothane is compatible with procaine and the combination of the two is suggested if an operation in the anal region is to be performed under infiltration alone. We are also of the opinion that an isotonic solution to replace the distilled water carrier should relieve immediate burning and possibly prevent chemical abscess. The one-half per cent strength appears optimum.

Since this contribution was submitted (May, 1934) further experience in a second hundred cases, in which procaine mixtures for very minor procedures and one-half per cent isotonic solution of diothane in the remainder have been used throughout, has tended to confirm the conclusions noted. No constitutional reactions have been noted, initial burning has been decreased but not eliminated by adding procaine to the mixture or the use of a preliminary infiltration of procaine, tag formation has continued to be noted in a modest percentage of cases but abscess has not been encountered when isotonic solutions were injected.

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EDITORIALS

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TOTAL THYROIDECTOMY FOR HEART DISEASE

THE prolonged discussion at the recent Toronto meeting of the American Surgical Association concerning total thyroidectomy[1] emphasizes the possibility of this new therapeutic measure. Following the suggestion of Blumgart and Levine that removal of the thyroid gland might prove of value in the treatment of intractable heart disease, some two hundred cases have by now been subjected to this procedure. The original impetus toward this undertaking emanated from both the laboratory and the clinic. Blumgart's careful and valuable studies concerning the factors controlling the rate of blood flow played a large rôle in arriving at the determination to perform thyroidectomy, for his experiments showed that the rate of blood flow was in a fairly constant relation to the basal metabolic demands of the body. Blumgart studied normal individuals and individuals in many pathological states. These studies indicated that when the basal metabolic rate was elevated (as in Graves' disease) the rate of blood flow was increased and, conversely, when the basal metabolic rate was lowered (as in myxœdema) the rate of flow was decreased. Reasoning from these findings and knowing that the rate of flow in intractable heart disease is slowed and indeed cannot be elevated in some cases by drug therapy, it appeared that, if the basal metabolic demands might be lowered by thyroidectomy, then these demands might find, even with the slowed rate of flow in decompensated heart disease, an adequate circulation. With the demand thus being dropped to meet a fixed rate of supply a certain equilibrium would be established and patients might be brought into compensation.

Another aspect of the reasoning which suggested removal of the normal thyroid gland for decompensated heart disease is wrapped up in the many and varied clinical observations of thyroid patients amassed during the last fifty years. By means of clinical studies we have been able to set aside from the great mass of cardiac cripples that group now commonly called thyreocardiac. In this group are those patients in whom the cardiac disability is due to repeated bouts of thyrotoxicosis. It has been demonstrated that such patients, when submitted to subtotal thyroidectomy, show an almost miraculous restoration to a practically normal condition. These patients often manifest auricular fibrillation and both clinical and experimental observations have shown that under the stress and strain of thyrotoxicosis auricular fibrillation is a common occurrence. But our

[1] Mixter, Charles G., Blumgart, Herman L., and Berlin, David D. Results of 18 months' experience with total ablation of the thyroid for angina pectoris and congestive heart failure, Tr. Am. Surg. Ass., 1934.
Cutler, Elliott C., and Schnitker, Max T. Total thyroidectomy for angina pectoris. Tr. Am. Surg. Ass., 1934.

clinical observations relate not only to these obvious cases of thyroid intoxication, for further reasoning is seen in the general attitude of both physicians and surgeons who place little reliance upon the basal metabolic rate as an indication of thyroid activity. For example, Wilson, in a study of patients with cardiac irregularities, has been able to make the diagnosis of thyrotoxicosis (Graves' disease) long before the basal metabolic rate has become elevated. Still further the thyroid gland has been attacked in cases of tachycardia with benefit to the patient and as one searches the thyroid literature of the last twenty years one finds more observations which definitely demonstrate a relation between cardiac activity and thyroid function not always measurable in terms of the basal metabolic rate.

The studies now reported from the Peter Bent Brigham Hospital and the Beth Israel Hospital of Boston seem to demonstrate a fulfillment of the predictions originally made by Blumgart and Levine. Patients in decompensation, whether from arteriosclerotic heart disease or valvular disease, have been greatly benefited by total removal of the normal thyroid gland. In the first cases studied, subtotal thyroidectomy was performed, but long continued observation showed that eventually, as the thyroid function was replaced, apparently by a regrowth of the tissue, and as the basal metabolic rate was restored to normal, the improvement disappeared.

It does seem as if, in the group of cardiac decompensation cases, the benefit which results is in definite relation to the lowered basal metabolic rate. Many bedridden patients have by now been submitted to this procedure and, as their basal metabolic rates have fallen and thus the demands upon the circulation decreased, they have finally reached a point where the lowered demands find even in the crippled cardiac situation an adequate supply.

Of particular interest are the results reported in patients suffering from angina pectoris. For example, in this group the circulation is already adequate and the benefit which has been achieved may not be in relation to the lowering of the basal metabolic demand. This is of great interest and may exemplify the growing tendency in both physicians and surgeons to separate as functions of the thyroid gland (1) the factors which dictate the basal metabolic demands, and (2) the factors which seem to bear a definite relation to circulatory changes irrespective of the basal metabolic demands. The studies reported by Cutler and Schnitker showed that in the angina pectoris group there were many people in whom the relief of pain bore little relation to the basal metabolic rate. Their observations revealed an immediate reduction in the amount of pain occurring many weeks before the basal metabolic rate fell. They showed also that many of these patients could be fed thyroid extract and their basal metabolic level brought practically to normal without return of pain. In extenuation of their belief that the factor controlling the basal metabolic rate is quite separate from the factor dealing with the circulation manifestation, they discussed the experimental results of Shambaugh who showed that adrenalin apparently is an important factor in the production of cardiac pain. This relation of adrenalin they thought was affected by thyroidectomy and they reported that patients in whom anginal attacks had been provoked by the subcutaneous injection of adrenalin failed to show pain when a similar amount of adrenalin was injected immediately following total thyroidectomy and at a time when the basal metabolic rate was still normal. It appears from these studies that possibly the basal

metabolic rate is not the best or only measuring-stick for the effect produced upon the circulation by total thyroidectomy. The relief afforded seems to be due, in part at least, to a diminished adrenalin activity associated with the loss of thyroid gland secretion.

The operation of total thyroidectomy as now performed carries certain dangers, chiefly those due to deprivation of the parathyroid function by removal of these glands (i.e., tetany, etc.), and injury to the recurrent laryngeal nerves. Apparently, parathyroid tetany has not proved to be a serious obstacle since no one has reported grave cases of tetany. It should be impressed on others, however, that the surgeons working with this problem have taken great precautions, including even histological examination of all questionable tissue at the time of the operation in order to leave the parathyroids in the patient or, if they have been removed, to replace them in the pretracheal or sternomastoid muscles. Moreover, the knowledge that the feeding of viosterol and calcium lactate by mouth can largely counteract the effects of parathyroid deprivation may give us greater confidence in the treatment of patients in whom these important structures may be injured or removed. The matter of injury to the recurrent laryngeal nerves has also been given particular attention and those surgeons most interested in this procedure have settled upon the use of local anæsthesia (procaine one per cent) in order that the patient may talk during that part of the procedure when the recurrent nerves are exposed and therefore in danger of injury. With complete exposure of the recurrent nerves and adequate hæmostasis it is apparent that this difficulty can be overcome.

There is, over and above the addition of this new therapeutic measure in the treatment of heart disease, a psychological shift which indicates a departure in surgical undertakings of considerable moment, for here we have an operation deliberately planned and undertaken for the relief of a pathological viscus in which that viscus itself is not approached. This operation, which plans to relieve the heart, consists in the attack upon a perfectly normal structure and almost for the first time we see the surgeon with full appreciation of physiology carrying out a physiological rather than an anatomical operation. As science gives us knowledge we can hope that other procedures aimed, not at the diseased part, but at parts controlling the function in the diseased organ may be further elaborated. Thus by shifting a little the activities of Nature we shall see Nature herself adjust the diseased organ to a more desirable activity and condition.

ELLIOTT C. CUTLER.

METALAPAROTOMY FUNCTIONAL ILEUS[1]

THE importance of the adynamic ileus which occurs following every laparotomy is not sufficiently appreciated. This ileus, which may be termed "functional" results either from direct trauma to the intestine or from stimulation of the splanchnic nerves which are inhibitors to the gut. As has been shown repeatedly both experimentally and clinically manipulation and exposure of the abdominal viscera to air cause an inhibition of intestinal movement and loss in tone. That such an inhibition exists for a period of time after operation is not generally appreciated, however, and it is the failure to recognize this ileus which is frequently responsible for a disturbed convalescence. As in all types of ileus, there is in addition to the decrease in tone and movement of the gut a diminished

[1] From the Department of Surgery, School of Medicine, Tulane University, New Orleans.

absorption from, and an increased secretion into, the intestine. The intestinal tract is functionally inactive. This type of ileus should not be confused, however, with the adynamic ileus which is associated with peritonitis, although the two differ only in degree and extent.

The duration of this physiological ileus varies considerably and is dependent largely upon the amount of intra-abdominal trauma during the operation. Normally in cases in which there is relatively little intra-abdominal operative manipulation, such as occurs during the removal of the appendix for a chronic appendicitis, the functional ileus persists for from six to twelve hours. If during this period of time the gastro-intestinal tract, while functionally inactive, is kept empty and not overloaded by the administration of fluids or food either by mouth or by rectum, the gut rapidly regains its tone and movement.

There may be no clinical manifestations of metalaparotomy functional ileus. Occasionally, however, nausea and vomiting are present, although these are not marked unless fluids or food have been allowed. The prognosis is good if the gastro-intestinal tract is allowed to regain its tone before the ingestion of substances. Altogether too frequently the anæsthesia is blamed for the postoperative nausea and vomiting even though it may be a contributory factor.

In the treatment of postoperative functional ileus it must be realized first that such a condition exists. As the gastro-intestinal tract is functionally unable to receive any material, it is imperative that absolutely nothing be given by mouth; water and, even more emphatically sweetened drinks which are apt to produce abdominal distention as a result of fermentation should be avoided. Morphine should be administered liberally after operation (in the case of an adult unless some contra-indication exists the patients should receive one-fourth grain of morphine sulphate every four hours whether they complain of pain or not), because, as has been shown repeatedly both in the laboratory and in the clinic, morphine increases the intestinal tone and does not inhibit the gut as is commonly thought. The morphine should be continued as long as there are any signs of ileus. All patients who have had an abdominal section should have a heat tent applied to the abdomen, because, as has been shown by Mueller, the application of heat to the abdomen causes a dilatation of the somatic vessels and a concomitant contraction of the splanchnic vessels. Associated with the contraction of the splanchnic vessels there is a decreased secretion into and an increased absorption from the gut and an increase in the tone of the gut wall. Heat applied to the abdomen, therefore, is beneficial in preventing and in combating ileus.

In those cases in which operation has been done on the gastric, the upper intestinal, and the biliary tracts, there frequently occurs an increase in gastric, intestinal, and biliary secretions. Because of this it is imperative to empty the stomach and upper portion of the intestine of its secretions in order to prevent stagnation and overdistention of the gut. This is best accomplished by means of continuous suction through an indwelling duodenal catheter, as suggested by Wangensteen and Bartlett. The duodenal aspiration should be continued as long as there is any evidence of increased secretion and stagnation, or during the period of pyloric imbalance (Bartlett).

As the metalaparotomy functional ileus persists usually only from six to twelve hours, it is possible after this period of time to allow the administration of fluids by mouth. These

should consist of hot water, hot tea, or fat-free broth. If these are tolerated, the patient's diet can be increased rapidly so that on the second or third morning, unless there is continued irritation of the peritoneum, the patient can usually tolerate a full diet. Sweetened drinks should not be allowed for approximately a week because of the fermentation and intestinal distention which they are apt to produce. If metalaparotomy functional ileus is considered and observed, the incidence of postoperative distention will become markedly diminished and even abolished except in those cases with peritonitis in which there is a continued peritoneal irritation.

ALTON OCHSNER.

VIVISECTION

THE subject of preservation of the right to use animals for experimental purposes is again before us in an acute form. We are informed that there is to be an organized effort to outlaw vivisection. The American College of Surgeons is prepared to combat with all of its energy any movement that has for its purpose interference with the progress of scientific preventive and curative medicine.

The College contemplates the publication of a synopsis of the advantages of, and necessities for, a continued use of animals for medical purposes—some for purely experimental purposes, and some for biologic assays of drugs and pharmaceuticals, preparation of sera and vaccines, biologic tests, teaching of surgical procedures, etc. This publication will be widely distributed where it is thought the greatest good may be accomplished in counteracting the attempts to cripple the medical profession and endanger the lives of the entire population.

Attention is directed particularly to the article entitled "Health Benefits from Animal Experimentation" which will be found on pages 838 to 840 of this issue of SURGERY, GYNECOLOGY AND OBSTETRICS.

FRANKLIN H. MARTIN.

EARLY AMERICAN MEDICAL SCHOOLS

THE MEDICAL SCHOOL OF THE UNIVERSITY OF LOUISVILLE

IRVIN ABELL, M.D., F.A.C.S., Louisville, Kentucky

THE history of the Medical School of the University of Louisville is closely linked with that of Transylvania Medical School since the organization of the former was largely effected by members of the faculty of the latter who desired the greater facilities afforded by Louisville over those then existing in Lexington. Transylvania University was established in Lexington, Kentucky, in 1780; in 1799 a medical school was added with the appointment of Drs. Samuel Brown and Francis Ridgely as professors therein. From 1799 to 1817 various appointments were made in the medical department and partial courses of lectures delivered. Following this year the school entered upon a remarkable career of service. In addition to Drs. Brown and Ridgely its faculty embraced a coterie of other brilliant teachers, among whom are found Benjamin Winslow Dudley, internationally known surgeon; James Bush, pioneer lithotomist; William Hall Richardson; the erratic but brilliant Charles Caldwell; John Esten Cooke, known for his humoral theory of disease and his heroic dosage of calomel therefor; Daniel Drake, who with Samuel Brown was a great internist of his day, Brown, in 1802, four years after Jenner announced his discovery of vaccination, having vaccinated more than 500 patients; Constantine Samuel Rafinesque, world known botanist; Charles Wilkins Short, a botanist of national repute; L. P. Yandell, Sr., chemist, forceful writer and accomplished speaker, sire of a distinguished generation of Kentucky doctors; Robert Peter, who "performed a greater number of reliable, detailed, practically useful analyses of the soil than any living chemist of his time"; John Eberle, teacher and writer of medicine; Thomas D. Mitchell, teacher in the schools of Kentucky and Philadelphia; Nathan Ryno Smith, who later returned to Baltimore, where, as surgeon and teacher in the University of Maryland, he established an enduring fame; William Short Chipley, distinguished alienist, and others of lesser attainments. During the 39 years of its active existence the medical school taught 4,656 pupils and conferred the degree of doctor of medicine on 1881 of that number, a contribution in medical education of the day of incomparable value. The library of Transylvania today contains one of the rarest collections in this or any country of books and manuscripts published during the seventeenth and early part of the eighteenth centuries. The Medical School of the University of Louisville when founded was known as the Medical Institute of the City of Louisville (Fig. 1) a charter being secured from the State Legislature with the assistance of Dr. Alban Goldsmith, a former associate of Dr. Ephraim McDowell. The law authorizing the establishment of the "Institute" was approved on February 2, 1833. Section 6 of the original act is interesting in that it provided for clinical instruction, an advanced step at this period of medical education. "Section 6. That the trustees of the Louisville Marine Hospital may confide the medical department of said hospital to the Institute, and the Mayor and Council of the City of Louisville may confide the medical department of the poor house and hospital to said Institute." The difficulty in securing

Fig. 1. The Medical Institute of the City of Louisville, January 1, 1839.

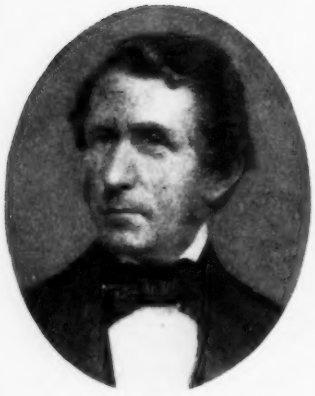

Fig. 2. Daniel Drake, 1785–1852.

Fig. 3. Professor Samuel D. Gross, 1805–1884. (From photograph made in 1860.)

Fig. 4. Dr. Austin Flint, Sr., 1812–1886.

medical teachers of recognized ability combined with the lack of adequate financial backing continued to delay the opening of the Institute. Because of Louisville's strategic river location, rapidly increasing size and consequently greater clinical facilities, six members of the Transylvania Medical Faculty, during the first part of the 1836–37 session discussed and apparently unanimously agreed upon the advisability of its removal to Louisville. This action precipitated a rather acrimonious fight involving the faculty, the trustees, and the citizens of Lexington which had as one of its results the opening of the Louisville Medical Institute in 1837 with the following faculty: Henry M. Miller, a graduate of Transylvania, professor of obstetrics and diseases of women and children; Charles Caldwell, a graduate of the University of Pennsylvania, professor of the institute of medicine and clinical practice and medical jurisprudence; John Esten Cooke, a graduate of the University of Pennsylvania, professor of the theory and practice of medicine; Lunsford Pitts Yandell, Sr., a graduate of Transylvania, professor of materia medica, lecturer on chemistry and dean of the faculty; Joshua Barker Flint, a graduate of Harvard, professor of surgery; Jedediah Cobb, a graduate of Bowdoin, professor of anatomy. At the close of the first session Dr. Charles Wilkins Short of Transylvania assumed his duties as professor of materia medica and medical botany while Yandell became professor of chemistry and pharmacy. At the opening of the third session Dr. Daniel Drake (Fig. 2) then internationally known, accepted the professorship of clinical medicine and pathological anatomy. During his stay in Louisville he completed his monumental work, *A Systemic Treatise, Historical, Etiological, and Practical on the Principal Diseases of the Interior Valley of North America, as they appear in the Caucasian, African, Indian and Esquimaux Varieties of its Population.* He had devoted more than 30 years to the preparation of this work, the first volume of 878 pages illustrated with nineteen plates appearing in 1850 and the second one of 985 pages in 1854.

On April 23, 1846, the University of Louisville was founded with two departments, the department of medicine and the department of law and by amendment of the charter the Louisville Medical Institute constituted the Medical Department. In 1840, Dr. Joshua B. Flint resigned as professor of surgery and was succeeded by Dr. Samuel D. Gross (Fig. 3), a graduate of Jefferson Medical College (1828). With the exception of one year, 1850, when he was professor of surgery in the University of the city of New York, during which time the chair in Louisville was filled by Dr. Paul F. Eve, Dr. Gross remained as head of the surgical department for 16 years. During this time, under the stimulating influence of his leadership, assisted by his colleagues in the University, notably Daniel Drake and Austin Flint (Fig. 4), Louisville became the leading medical center of the West. Most of the work on his monumental system of surgery was done during these years. His work on *Diseases, Injuries and Malformations of the Urinary Organs* was published in 1851 followed by that on *Foreign Bodies in the Air-passages* in 1854.

During the greater part of the past century the system of medical education consisted of apprenticeship and attendance upon lectures. There

Fig. 5. The present Medical School building.

were but few hospitals, medical literature was in its infancy, and the advantages and opportunities afforded by the medical societies of today were unknown. The professors in the medical colleges were the accepted leaders, hence men of ability sought such positions as a means of winning recognition and distinction. With such conditions prevailing, it was but logical that with the growth of Louisville as a medical center the number of men aspiring to teaching positions became so great as to result in the establishment of new schools. The Kentucky School of Medicine was founded in 1850, the Louisville Medical College in 1868, the Hospital College of Medicine in 1873, and the Medical Department of Kentucky University in 1898. The list of men who taught in the five schools is a long one: the writer would select the following as distinctive, classifying them by their spheres of activity. Deans: J. M. Bodine, W. H. Wathen, C. W. Kelly, P. R. Taylor and T. C. Evans. Surgery and Clinical Surgery: J. B. Flint, S. D. Gross, P. F. Eve, B. R. Palmer, D. W. Yandell, A. B. Cook, R. O. Cowling, Tobias G. Richardson, W. O. Roberts, H. H. Grant, W. L. Rodman, J. M. Holloway, A. M. Cartledge, Turner Anderson, L. S. McMurtry, Joseph Matthews, and W. H. Wathen. Medicine: Austin Flint, Charles Caldwell, Daniel Drake, John E. Cooke, T. S. Bell, L. P. Yandell, James W. Holland, Samuel Bemiss, John A. Ouchterlony, W. H. Galt, George Warner, E. D. Foree, Lewis and Coleman Rogers, William Bailey, F. C. Wilson, J. B. Marvin, John G. Cecil and P. B. Scott. Obstetrics and Diseases of Children: Henry Miller, John E. Crowe, John Hardin, Theophilus Parvin, H. B. Ritter, W. H. Bolling, J. A. Ireland, H. E.

Fig. 6. Louisville City Hospital, 1934.

Tuley. Anatomy: Jedediah Cobb, J. W. Benson, J. D. Burch, G. W. Bayless, C. W. Kelly, and J. M. Bodine. Physiology: H. M. Bullitt, E. R. Palmer, Sam Cochran. Chemistry: L. D. Hostenbine, Benjamin Silliman. Ophthalmology, otology and laryngology: Dudley S. Reynolds, M. F. Coomes, J. M. Ray, William Cheatham, T. C. Evans, P. R. Taylor. Dermatology: I. N. Bloom.

Of these Drs. Samuel Gross, Theophilus Parvin, James Holland, and William Rodman removed to Philadelphia; Dr. Austin Flint to New York, and Drs. Tobias Richardson and Samuel Bemiss to New Orleans, in which cities they enjoyed distinguished careers as leaders in the profession. These men taught during a transition period and were the connecting links between the old and new eras. With the advent of the laboratory, the growth of biology, chemistry and physiology, and the development of the modern hospital, medicine ceased to be empirical, became more and more a science, and medical education conformed to the inevitable change. In 1908 these five schools were merged into one under the title of the University of Louisville School of Medicine. With the union of the various schools the building which had been used by the Louisville Medical College, located on First and Chestnut Streets, was taken over and has served for the teaching of the preclinical subjects up to the present time (Fig. 5). In 1922 an agreement was made between the City Fathers and the Board of Trustees of the University of Louisville, whereby the professional work of the Louisville City Hospital, an institution of 400 beds (Fig. 6), was placed entirely under the direction of the School of Medicine. Previous to this agreement the faculty of the medical school was appointed to serve in the hospital only during the school year; during the summer months other physicians were appointed by the Board of Public Safety to care for the sick. All of the various services necessary for the adequate care of patients and for teaching, together with offices for full time clinical faculty, are housed in this hospital.

In 1930 teaching affiliations were made with the Waverly Hills Tuberculosis Sanatorium, a modern charitable institution with a capacity of 440. It is located some seven miles outside of the city and the students live and work there during a few weeks of their training. In 1932 an affiliation similar to that with the Louisville City Hospital was made with the Childrens' Free Hospital (75 beds), which has facilities for the care of medical, surgical and orthopedic cases. This hospital is across the street from the City Hospital, an ideal situation for the proper distribution of patients between the two institutions. In this same year responsibility for the maintenance and development of the Psychological Clinic, which had been conducted for about ten years by an organization of the Community Chest, was assumed by the Psychiatric Department of the School of Medicine. The out-growth is the Mental Hygiene Clinic, housed on the grounds of the Children's Free Hospital. Shortly afterward the department of public health and bacteriology of the medical school assumed control of the department of epidemiology of the City Health Office and in 1934 it took over the City's Department of Bacteriology. Such arrangements preclude political interference and allow easy access to teaching material.

It will be seen that the School of Medicine, through its affiliations, has 915 beds for purposes of instruction. There are available to the students, in addition, 150,000 dispensary patients a year. The faculty at the present time consists of 127 members, 65 of which are of professorial rank; of these 17 are on a full-time basis. The minimum requirement for admission is 60 semester hours of collegiate work, as fixed by the Association of American Medical Colleges. The classes are limited to 90 students each and the average enrollment in the school is 350.

The University of Louisville, as a municipal institution, receives by law 5 to 7 mills of the taxes collected by the city, but this covers not more than 35 per cent of the total operating expense. The remainder is paid from endowments, donations, and student fees. The University, which began with the School of Medicine in 1837, added during the succeeding years, the School of Law in 1846; the College of Liberal Arts in 1907; the School of Dentistry in 1918; The Speed Scientific School in 1924; and the School of Music in 1932. At the present time the enrollment for the entire University is in the neighborhood of 1800 students.

The author wishes gratefully to acknowledge the aid of Dean John Walker Moore and Dr. Clarence Bird, head of the department of surgery, in the compilation of the above data.

THE SURGEON'S LIBRARY

REVIEWS OF NEW BOOKS

THE excellent text on *Surgical Anatomy*[1] by Callander is broadly conceived and well carried out. The author's purpose has been to "present anatomic facts in terms of their clinical importance," to produce a book which would be explanatory and utilitarian rather than encyclopedic. The difficulty of such an undertaking is at once appreciated by anyone who has attempted to teach surgical anatomy, a course which is too often either entirely anatomy or entirely one of surgical technique. To be quite truthful, it is not always easy to say just what surgical anatomy is, anyway. Dean Lewis feels that the two subjects of surgery and anatomy are so inseparably bound together that in his preface to the volume he writes: "In medical schools the surgical department should hold itself responsible for the proper approach to gross anatomy." For that matter, so should the departments of internal medicine, ear, nose and throat, eye, obstetrics and gynecology, and all other departments.

Callander succeeds in the task he set out to accomplish. The book is made up in ten sections, each covering a definite region of the body. In each section, the region is further divided into subdivisions, each of which is taken in turn and discussed from the anatomical and then from the surgical standpoint. The book is replete with excellent illustrations, many new and many reproduced from numerous sources. The selection of these illustrations is most happy in that not only do they represent anatomy, but surgical procedures which emphasize the importance of the anatomy. The text is clear, brief, and readable. Despite its rather large size and expense, the book is to be recommended to students as well as to the surgeon.

MICHAEL L. MASON.

IN this work[2] on physical therapy, Wolf has gathered together the results of his experience in all branches of physical therapy during his 30 years of medical practice. The book is packed full of useful information and is a valuable textbook on this important branch of therapy.

The author believes that routine treatment in physical therapy is a dangerous procedure, impractical, and inefficient, and that physical therapy must be used on its merits alone. He has therefore made a special effort to tell why he uses a certain method in a specific case.

Dr. William Bierman, director of physical therapy, Beth Israel Hospital, New York, has written excellent chapters on the therapeutic use of hyperthermia and minor electrosurgery. The use of physical agents in diseases of the lower respiratory tract is considered in a chapter by Dr. Adolph A. Lilien, associate physical therapist, Mt. Sinai Hospital. Physical therapy in otolaryngology is the subject of a chapter by Dr. Farel Jouard, adjunct physical therapist, Mt. Sinai Hospital.

The first part of the book by the author is devoted to a consideration of the theory and principles of physical therapy, with a specially valuable chapter on hydrotherapy. Dr. Wolf has had a long experience in the use of this valuable agent, and he rightly states that hydrotherapy can be practiced on a far better and safer scientific basis than can the majority of our medications.

In part 2, which discusses the practice of physical therapeutics, Dr. Wolf has carefully given the technique for the use of physical therapy in the various diseases and injuries in which it is indicated. He gives conservative discussions of the uses of physical agents and quotes illustrative cases.

The last chapter, on the use of physical agents in gynecology, is by Dr. Madge McGuinness, chief of clinic, Department of Physical Therapy, Vanderbilt Clinic, and director of physical therapy, Misericordia Hospital, New York.

This book can be recommended as an excellent textbook for the student and general practitioner.

J. S. COULTER.

WHENEVER a new volume on surgery is forthcoming from any of the great German clinics, the American profession has been accustomed to anticipate something well worthwhile. In the recent work[3] of Dr. Payr we are not disappointed; it represents practically the life work of a man who is eminently qualified by his vast surgical and clinical experience, under conditions of war and peace, to speak with authority on his chosen subject.

In the introductory chapter, Dr. Payr states that he intended originally to present only the technique

[1] SURGICAL ANATOMY. By C. Latimer Callander, A.B., M.D., F.A.C.S. With a Foreword by Dean Lewis, M.D., Sc.D., LL.D., F.A.C.S. Philadelphia and London: W. B. Saunders Co., 1933.

[2] TEXTBOOK OF PHYSICAL THERAPY. By Heinrich F. Wolf, M.D. Foreword by L. F. Baker, M.D. New York and London: D. Appleton—Century Co., Inc., 1933.

[3] GELENKSTEIFEN UND GELENKPLASTIK. By Professor Dr. Erwin Payr, Vol. i—Pathologische biologie der gelenke; Pathogenese und pathologische Anatomie der Ankylosen; klinik Diagnostik und anzeigestellung. Berlin: Julius Springer, 1934.

of plastic surgery in ankylosis. Soon, however, he found that this could not be covered thoroughly without including a résumé of the pathogenesis and pathological anatomy of ankylosis, and in particular the indications for surgery, because upon proper selection of cases depends the successful management, by whatever therapy.

The original plan contemplated the conclusion of the first volume with the general operative technique, but as the work proceeded the scope of the subject became so vast that this section, together with special operative procedures, has been left for a second volume, although in many places reference has been made to operative management. Dr. Payr has viewed the problem of reconstruction of the joint in ankylosis from every conceivable angle, and has given a complete dissertation on each phase, thus presenting in one volume all the essential principles of the study of plastic surgery in ankylosis. We may look forward to the second volume, wherein operative procedures will be considered, with equal anticipation.

He has given us, in great detail, the consideration of the pathological anatomy, physiology, histology, and mechanical anatomy of the joints. His subdivisions of the problem are many: he discusses congenital and accidental factors, septicæmia, the ankylosis due to inactivity, infection, and asepsis; and such co-existing factors as arthritis, gout, tuberculosis, and lues. The chapters devoted to animal experimentation, in its application to plastic surgery on man, are exceedingly interesting. Here he studied the production of ankylosis, with the resultant pathological, histological, and anatomical findings, and he carried the work forward to observations on the physiological regeneration of the joints, of the joint capsules and ligaments, and of the synovia.

Of great practical interest is the discussion of methods of investigation from the standpoint of diagnosis, wherein are enumerated clinical and bacteriological laboratory studies, the interpretation of X-ray findings, and the evaluation of these investigations in the diagnosis and prognosis.

His theories on the regeneration of the joint as a whole and in part are sure to arouse widespread discussion among men in this country who have been working along similar lines, as many of his concepts are entirely new to us. Particularly apropos at this time is his discussion of arthritis in relation to ankylosis, and the question of focal infection, endocrine influence, and general constitutional factors.

The book is beautifully illustrated. For the man who reads it in the original German, it will be a treasure trove; on behalf of the great majority who do not read German, the hope is expressed that when it comes to translation, as it unquestionably should, it falls into the hands of someone who will do it justice.

As is to be expected, there is an elaborate and altogether satisfactory index.

WILLIAM A. HENDRICKS.

IN the introduction to *Some Aspects of the Cancer Problem*, W. Blair Bell states—"It is clear that Man can survive in the progress of evolution only so long as his intellect and accumulated knowledge are sufficient to enable him to overcome the physical and mental stresses and injuries that follow in the wake of civilization, and can deal successfully with the host of organic pathological processes that may prey upon him. . . . Is our intelligence great enough, and our store of knowledge sufficient to enable us to conquer this menace (cancer)? If they are, mankind will endure for another season; if they are not, we can hardly foresee what fate may be in store for the human race."

Man has made an unrelenting fight against cancer during the past hundred years, the problem being approached in many ways; nevertheless there is an apparent increase in cancer prevalence. Comparatively little attention has been addressed to the spread of cancer, especially in the form of a careful study of the character of the metastatic lesion and the fate of cancer cells when deposited in foreign soil. Willis, in a carefully prepared monograph[1], adds a distinct chapter to our present knowledge of this important phase of the cancer problem. He states in the preface of this work: "No comprehensive account of the mode of extension and metastasis of tumours is available. Textbooks of pathology touch but lightly on the subject and ignore many of the problems presented by it, and special works on oncology view tumours chiefly from the aspect of their primary origins and not from that of their metastatic destination. . . . Much experimental work has been devoted to a study of the fate of tumour cells artificially injected in various situations in animals. In the spontaneous metastasis of tumours, nature displays to us in the human being a great variety of such experiments already performed and presenting a series of end-results, the meaning of which it is our task to interpret. It may be that this interpretation, heretofore but little assayed, may uncover some of the secrets of neoplastic growth."

Willis bases his conclusions upon a careful study of 323 personally conducted autopsies in cases of malignant disease and upon a most painstaking investigation of the literature, his bibliography covering 83 pages. A synopsis of the autopsy protocols is given in an appendix. The book is divided into two parts: Part I is devoted to the consideration of the general aspect of the spread of tumors and Part II to secondary neoplastic tumors of the individual organs and tissues. Many interesting avenues of thought are opened in the consideration of these topics, two of which impressed themselves upon the reviewer: The care in deciding whether a tumor is primary or secondary especially when a surgical removal is being contemplated and the vagaries displayed by blood borne tumor cells. It is a strange incongruity that tumor cells rarely grow to form metastatic neoplasms

[1] MONOGRAPHS OF THE BAKER INSTITUTE OF MEDICAL RESEARCH, THE SPREAD OF TUMOURS IN THE HUMAN BODY. By Rupert A. Willis, M.D., B.S., D.Sc. London: J. & A. Churchill, 1934.

in the skeletal muscles while in bone the incidence is high, that emboli of tumor cells may be found in the lungs and other tissues without any evidence of activity, and that certain tumors metastasize to select tissues, as an example, prostatic and thyroid cancer to the bone. The author is of the opinion that the quality of the various host tissues are of prime importance and that the anatomy of the circulation fails to explain it. The hypothesis is offered that "different tumours have different optimal requirements and therefore exhibit different metastatic distributional behavior," also that oxygen tension and carbohydrate supply in different tissues are important factors as regards metastasis. Every phase of the process of the spread of tumors is discussed in detail.

In Part II an excellent discussion of secondary tumors of individual organs and tissues is given. No one chapter can be singled out; however, that devoted to secondary tumors of bones is extremely interesting and instructive. Much valuable information is incorporated relative to statistics, frequency of occurrence, the nature of the metastatic growth, gross and microscopic appearance of the lesion, disturbance of function, and rate of growth. Illustrative case reports are cited. It might be added that the 323 reported autopsies were done following a technique designed for the special purpose of ascertaining as completely as possible the modes of extension of the tumors and the situation of their metastases.

For anyone interested in malignant disease this work is a source of inspiration and help. It is amply illustrated; many instructive photomicrographs and photographs of tumors are included. Beyond question this work adds to our store of knowledge and is a step in a new direction in the study of malignant disease in the great effort to allow mankind to endure for another season. JOHN A. WOLFER.

OUT of the South from the pen of two young orthopedic surgeons comes this lengthy volume on *The Management of Fractures, Dislocations, and Sprains.*[1] One of them is an aggressive clinical professor in St. Louis, the other a practical surgeon for the Tennessee Coal, Iron and Railroad Company in Alabama, unhampered by academic restrictions in his first book flight. Although thus separated, the authors have made a book giving advice reasonably personal, expressing stands for and against lines of treatment resolutely. When a difference of opinion in treatment of specific conditions exists between them, such differences are often boldly expressed in successive sentences, frequently without explanation. To a student this may be confusing; to the experienced surgeon it is a confession of faith that the book itself is tangible proof that a friendly difference of opinion, in their latitude, leads to even greater things than horse races.

The book is written in a pleasant, rather casual, readable tone which, however, is intimate in its view of the workings of the authors' minds in most decisions but not in all. All subjects guaranteed by the title are covered within its 1164 pages and 1165 illustrations, and the reader should be able to find information on every point, although the division of topics in so extensive a field may seem a little jerky and distracting.

Very few missteps can be found in this meaty volume. One might desire to see more and specific references to the literature quoted; to the student a well organized plan of volume and page figures are time saving essentials in further study.

The experienced reader may find all up to date treatment methods described but may question the advisability of some of the therapeutic advices such as the use of calcium salts in the healing of wounds of osteomyelitis or the description of the head of the humerus fitting into the glenoid cavity. In the light of constant changes of law and custom in our many states the exact value of the two short chapters on the Workmen's Compensation Law and the medico-legal aspects related to these injuries seem uncertain in a text of this character. Likewise the statement is made that the X-ray should be used in all doubtful cases (of fractures?) yet the authors think that the physician should be permitted to use his own judgment as to whether or not X-ray pictures are necessary in a given case. If he errs he cannot be held liable if he has used his own best judgment. This rather dangerous statement is not concurred in by the various fracture committees and medical bodies in the United States because it furnishes a great stumbling block to practitioners, leads to mistaken diagnosis, insufficient care, and the lawsuits which have been the bugbear of this branch of surgery.

The format of the book is pleasing but ponderous and for its weight the binding seems a little inadequate. Possibly the double paternity of the volume leads to some superfecundity as shown by sets of twin pictures, figures 199 and 247, and 823 and 886 being identical. This treatise is admirably done, it reflects the efforts of those who in the last 20 years have laboriously endeavored to raise both standards and interest in the treatment of fractures.

KELLOGG SPEED.

IN the English speaking countries, the induction of narcosis for surgical purposes has largely become a specialty, and professional anæsthetists, physicians or otherwise, administer most of the surgical anæsthetics. In central Europe, however, the giving of anæsthetics is still a function of the surgeon, and one which is usually relegated to the younger members of the clinic. The book[2] by Killian, a surgeon, is written for the instruction of those assistants entrusted with the administration of anæsthetics. It differs from the conventional American textbook in that the anæsthetic agents, throughout, are dis-

[1] THE MANAGEMENT OF FRACTURES, DISLOCATIONS, AND SPRAINS. By J. Albert Key, B.S., M.D., and H. Earle Conwell, M.D., F.A.C.S. St. Louis: The C. V. Mosby Co., 1934.

[2] NARKOSE; ZU OPERATIVEN ZWECKEN. By Dr. Hans Killian. Berlin: Julius Springer, 1934.

cussed as a whole rather than as individual substances with particular properties and special techniques. A brief discussion of the theory of narcosis precedes the practical considerations. The chapter dealing with functional and organic changes produced under anæsthesia is particularly detailed. The directions as to the selection of anæsthetic agents and the techniques for their administration are not sufficiently complete or detailed to serve as a practical guide in the management of narcosis. A series of diagrammatic tables is presented, however, which graphically indicates the clinical manifestations during the successive stages of narcosis with some of the more frequently used anæsthetics. A history of anæsthesia introduces the work, but many of the dramatic qualities of the story are lost in the telling. Furthermore, numerous minor misstatements limit the value of the historical review. Because of the difference in the type of reader for whom the work is intended, this book will probably find little use as a practical textbook in this country.

LEO M. ZIMMERMAN.

BOOKS RECEIVED

Books received are acknowledged in this department, and such acknowledgment must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

GENEALOGY OF SEX; SEX IN ITS MYRIAD FORMS, FROM THE ONE-CELLED ANIMAL TO THE HUMAN BEING. By Curt Thesing, M.D. Translated by Eden and Cedar Paul. New York: Emerson Books, Inc., 1934.

THE DANGEROUS AGE IN MEN; A TREATISE ON THE PROSTATE GLAND. By Chester Tilton Stone, M.D. New York: The Macmillan Company, 1934.

THE SURGERY OF THE SYMPATHETIC NERVOUS SYSTEM. By George E. Gask, C.M.G., D.S.O., F.R.C.S. (Eng.), and J. Paterson Ross, M.S. (Lond.), F.R.C.S. (Eng.). Baltimore: William Wood and Company, 1934.

A TEXTBOOK OF BACTERIOLOGY, etc. By Hans Zinsser, M.D., and Stanhope Bayne-Jones, M.D. 7th rev. ed. New York and London: D. Appleton-Century Co., 1934.

LABORATORY MANUAL OF BIOLOGICAL CHEMISTRY; WITH SUPPLEMENT. By Otto Folin. 5th ed. New York and London: D. Appleton-Century Company, 1934.

FUSS UND BEIN; IHRE ERKRANKUNGEN UND DEREN BEHANDLUNG. By Prof. Dr. med. Georg Hohmann. 2d ed. Munich: J. F. Bergmann, 1934.

POSTURES AND PRACTICES DURING LABOR AMONG PRIMITIVE PEOPLES; ADAPTATIONS TO MODERN OBSTETRICS, etc. By Julius Jarcho, M.D., F.A.C.S. New York: Paul B. Hoeber, Inc., 1934.

CANCER; EDINBURGH 1934. Published by The Cancer Control Organisation for Edinburgh and Southeast Scotland. Edinburgh: E. & S. Livingstone, 1934.

MATERNAL MORTALITY IN FIFTEEN STATES. United States Department of Labor, Children's Bureau. Bureau Publication No. 223. Washington: United States Government Printing Office, 1934.

TRAITEMENT CHIRURGICAL DES INSUFFISANCES OVARIENNES. By G. Jeanneney. Paris: L'Expansion Scientifique Française, 1934.

THE PROSPECTIVE MOTHER; A HANDBOOK FOR WOMEN DURING PREGNANCY. By J. Morris Slemons, M.D. 3d ed. New York and London: D. Appleton-Century Co., 1934.

THE OPERATIVE TREATMENT OF COLLUM FEMORIS FRACTURES. By Sven Johansson, M.D. Copenhagen: Levin & Munksgaard, 1934.

THE CYCLOPEDIA OF MEDICINE. George Morris Piersol, B.S., M.D., and Edward L. Bortz, A.B., M.D. Vol. x. Philadelphia: F. A. Davis Co., 1934.

A TEXTBOOK OF GYNECOLOGY. By Arthur H. Curtis, M.D. 2d ed. Philadelphia, London: W. B. Saunders Co., 1934.

THE SINISTER SHEPHERD; A TRANSLATION OF GIRALAMO FRACASTORO'S SYPHILIDIS SIVE DE MORBO GALLICO LIBRI TRES. By William Van Wyck. Los Angeles: The Primavera Press, 1934.

ESSENTIALS OF INFANT FEEDING AND PÆDIATRIC PRACTICE. By Henry P. Wright, B.A., M.D. London: Oxford University Press, 1934.

TRANSACTIONS OF THE SOUTHERN SURGICAL ASSOCIATION. Vol. xlvi. Forty-Sixth Annual Meeting. Edited by Robert L. Payne, M.D. New York: Paul B. Hoeber, 1934.

ATLAS FUNDUS OCULI. By William Holland Wilmer, M.D., LL.D., Sc.D. Introduction by Warfield T. Longcope, M.D. New York: The Macmillan Co., 1934.

A TEXTBOOK OF HISTOLOGY. By Harvey E. Jordan, A.M., Ph.D. New York, London: D. Appleton-Century Co., 1934.

A TEXT-BOOK OF PATHOLOGY. Edited by E. T. Bell, M.D. 2d enl. rev. ed. Philadelphia: Lea & Febiger, 1934.

THE AUTONOMIC NERVOUS SYSTEM. By Albert Kuntz, Ph.D., M.D. 2d enl. and rev. ed. Philadelphia: Lea & Febiger, 1934.

PRACTICAL TALKS ON HEART DISEASE. By George L. Carlisle, M.D. Springfield, Illinois, and Baltimore, Maryland: Charles C. Thomas, 1934.

INDUSTRIAL MALADIES. By Sir Thomas Legge, C.B.E., M.D. (Oxon.), D.P.H. (Cantab.). Edited by S. A. Henry, M.A., M.D., D.P.H. (Cantab.), D.T.M. (Liverpool). London: Oxford University Press, 1934.

A TEXTBOOK OF HISTOLOGY; FUNCTIONAL SIGNIFICANCE OF CELLS AND INTERCELLULAR SUBSTANCES. By E. V. Cowdry. Philadelphia: Lea & Febiger, 1934.

THE LIFE OF SIR ROBERT JONES. By Frederick Watson. Baltimore: William Wood & Co., 1934.

THE ANATOMY OF SURGICAL APPROACHES. By L. C. Kellogg, M.D. Baltimore: William Wood & Co., 1934.

THE RADIOLOGY OF BONES AND JOINTS. By James F. Brailsford, M.D. (B'ham), M.R.C.S. (Eng.). Baltimore: William Wood & Co., 1934.

HUMAN STERILITY, etc. By Samuel Raynor Meaker, M.D. Baltimore: The Williams & Wilkins Co., 1934.

PHYSICAL DIAGNOSIS. By Richard C. Cabot, M.D. 11th ed. Baltimore: William Wood & Co., 1934.

A TEXT-BOOK OF MEDICAL PSYCHOLOGY. By Ernst Kretschmer, Dr. Med. Translated by E. B. Strauss, M.A., D.M. (Oxon.). London: Oxford University Press, 1934.

COLLANA MANUALI DEL *Policlinico*. N.47. UROLOGIA PRATICA; COMPENDIO AD USO DEI MEDICI. By Dott. Prof. Ermanno Mingazzini. Preface by Prof. Roberto Alessandri. Rome: Luigi Pozzi, 1934.

AMERICAN COLLEGE OF SURGEONS

HEALTH BENEFITS FROM ANIMAL EXPERIMENTATION

ISSUED BY THE AMERICAN COLLEGE OF SURGEONS; PREPARED BY BOWMAN C. CROWELL, M.D.

IT is interesting to stand in the concourse of one of our large railway stations and watch the people who pass through it. How few bowed legs we see and how few are pock-marked! What clear eyes they all have! How few hunchbacks there are, and how few show disfiguring scars on the neck! Compared with conditions in this country at the turn of the last century, and in some foreign countries at the present time, this picture indicates an immense progress in the control of rickets, smallpox, trachoma, and tuberculosis of the spine and of the glands of the neck.

Each of us demands that our family physician shall be able to prevent sickness and, at any cost, shall do the most possible for us when we do get sick. It is impossible for him to take preventive or curative measures, surgical or otherwise, without using knowledge that has been gained from work on lower animals—mice, rats, guinea-pigs, rabbits, dogs, monkeys, birds, horses, cows, and other animals. The drugs and other remedial agents that he uses are tested and standardized on animals. Many of his diagnostic tests are performed on animals. His surgical technique has been perfected on them. New knowledge of practical value in health as well as in disease comes from them and must continue to come from them. Many of the protective and curative agents are manufactured within their bodies. Moreover, the benefit to animals themselves has been as great as has that to human beings. Epizootic diseases have been controlled, and preventive and curative measures have saved the lives of millions of animals. Now let us see what progress has been made by the use of animals and how it has been accomplished.

First we will go to the admitting office of one of our large hospitals and watch the stream of patients passing through. See the poor, thin, pale, nervous man with severe anæmia going in to see the medical man who will restore his color and strength with liver; the fat woman who has overindulged at the table and has avoided exercise, now suffering from diabetes; the nervous excitable woman with bulging eyes and a lump in her neck, a case of exophthalmic goiter; the poor dyspeptic with an ulcer of the stomach; the woman with the lump in her breast; and the line of young children coming in to go through the process of protection from smallpox, typhoid fever, diphtheria or scarlet fever, or to have their teeth and tonsils attended to in order to prevent future heart or kidney disease.

Preventive and curative scientific medicine can do much for them all. It can give promise of life to the case of pernicious anemia to whom fifteen years ago we could offer little more than pity, a great discovery that came as a climax to research which was started purely as a laboratory investigation into the coloring matter of the blood. Science can enable the diabetic to live a normal life after proper education in diet and the use of insulin, it can relieve the goiter case, and it can cure the stomach ulcer. Beaumont, a U. S. army surgeon, in 1825, had a patient who had been shot through the stomach and it was necessary to establish a permanent opening between the stomach and the abdominal wall. He seized this opportunity to study the process of digestion directly for the first time it had been done, and the results were of great importance. But how much more easily this can be done now on animals! We know that the lump in the breast can be removed and possible cancer prevented or early cancer cured. We also know that the children will be protected against many needless diseases by the preventive measures now so readily employed.

Let us move on to the laboratory and see the doctor examining the sputum for tuberculosis bacilli, the smear from the throat for diphtheria bacilli, the blood serum from the patient for evidence of typhoid fever, or syphilis, or relapsing fever, the intestinal contents for blood, mucus, amebae, round worms, flat worms or other parasites, the spinal fluid for evidence of infantile paralysis or other derangements of the nervous system, the stomach contents for evidence of ulcer or cancer, the tissue from the breast for

cancer or other tumor, the urine for evidence of nephritis or diabetes, and see him preparing the diagnostic and curative sera and vaccines for a number of diseases.

Next let us go to the pharmacy where the digitalis for heart trouble, the insulin for diabetes, the stock vaccines and sera, the castor oil and the viosterol, the Epsom salts and the soda bicarbonate are dispensed along with all the other drugs. Here let us pause and think that none of these preparations that are used so commonly would be safe to give to a patient unless they had been purified and standardized as to dosage or sterility by trying them on animals and determining their unit values.

A visit to the department of operative surgery in the adjoining medical school will be of great interest. Novitiates in medicine who already have studied their chemistry, biology, anatomy, physiology, pathology, and bacteriology, are being led by competent and experienced surgeons into the realm where they may become familiar with the appearance and feeling of living tissues and are learning the surgical technical methods of cutting, suturing, ligaturing, preventing infection, and bandaging, so that they may be fitted to save lives in emergencies. Here also we see the experienced surgeon, who has had an idea of some new surgical procedure that he thinks may be feasible, trying it out on some animal and perfecting his technique before attempting to cure the baffling human case that has been entrusted to his care. We will see the animals anesthetized, sterilized, and cared for with every precaution so that the outcome of the various procedures may be known without the occurrence of complications. On the wall are posted instructions as to the care of the animals. It is in rooms such as this that surgeons within very recent years have learned how they may open the skull and treat many diseases of the brain, how they may sever nerve roots to relieve intolerable pain, how they may sew up the ruptured heart or remove a diseased lobe of the lung, how they may remove the spleen or sew up the liver after a severe crushing accident, and also how to improve upon many older surgical procedures.

The anatomical structure and functional activities of many of the organs of the dog are so similar to those of man that it makes its use almost imperative in some studies. However, there is a voluntary restriction of its use by medical scientists to those cases in which some other animal would not serve the purpose as well or nearly as well.

Over at the veterinary station we will find all sorts of animals benefiting from the experimental work. Animals are subject to many of the same diseases as are humans, and their methods of prevention and treatment are similar. Moreover, the control of diseases that are peculiar to animals is as great an accomplishment as has occurred with human diseases. In serving others they have served themselves. In dogs distemper can be prevented and rabies can be reduced. In cattle tuberculosis easily can be detected and eliminated. Parasites can be removed. Anthrax, tetanus, and hog cholera can be prevented. All of these diseases have caused untold suffering and economic loss, which research has made needless, as, for example, in hog cholera which in 1914 killed 12 per cent of the swine in the United States, and against which it is now possible to obtain nearly 100 per cent protection.

What is worse than a rabid dog? What gives greater fear than the bite of a mad dog? Through the Pasteur treatment the dangers of hydrophobia have been reduced enormously, and the number of persons now annually treated for this disease mounts to the almost unbelievable number of hundreds of thousands. How many would hesitate thus to protect themselves after being bitten by a rabid dog even with the knowledge that their individual case will entail the sacrifice of several animals?

Having witnessed these evidences of progress, and knowing of much else that cannot be included in detail in a limited space—the great reduction in infant mortality and the control of infectious diseases, the purification of our water, milk, and food, which we all take for granted and by reason of which we continue to exist, the progress in the control of cancer, and the increase in the life span from 45 to 59 years within the past 35 years, with the prediction that it will be increased still further—let us pause a moment to consider some of the factors that have served to bring all this about.

If this preservation of health and increased longevity are to be continued then the use of animals must be allowed. Physicians have not hesitated to sacrifice themselves in experiments for the progress of science or to prove their theories. Very recently we have the example of Dr. Park of New York and his associates allowing themselves to be injected with the killed virus of infantile paralysis in order that their bodies might produce substances that would protect others against the disease. And still more recently Dr. Kolmer of Philadelphia has tested on himself and his two children what he believes to be a preventive against infantile paralysis. James

Carroll of the Walter Reed Yellow Fever Commission submitted himself to the bite of a mosquito infected with the yellow fever virus and came successfully through an attack of yellow fever. Not so fortunate was his fellow member on the Commission, Jesse W. Lazear, who was accidentally bitten by an infected mosquito during their experiment and died from the disease. Noguchi is another notable example of a martyr to science. Daniel Carrion, Dutton, Ricketts, and McClintic all lost their lives in investigating the diseases with which their names are associated.

Sir Frederick G. Banting proved his theory and developed insulin at the sacrifice of approximately thirty dogs. Today the lives of a million people have benefited from its use. John B. Murphy, in perfecting his method of sealing together the torn or cut ends of the intestine by an ingenious button, used fifteen or twenty dogs, and as a result countless human lives have been saved.

Such examples could be multiplied almost *ad infinitum*. We know that the medical scientists unselfishly have made possible all the progress of which we have spoken. We discern the unreasonableness and inconsistency of those who would hamper it when they daily eat fish, flesh, or fowl. We know the human and humane character of our medical fraternity who will sit up night after night with you when you need them, and we also know the conditions under which they practice animal experimentation.

Let me refer to only a few of them with reference especially to dogs. Only derelict or condemned dogs from the pounds are so used, and not the pets of ourselves or our friends or even of our enemies. In order to be allowed to obtain dogs for experimental purposes an institution first must submit to thorough investigation before approval is given.

Laboratory workers have drawn up sets of rules for the care of the dogs and these are adhered to rigidly. The dogs really live lives of luxury compared to ordinary street life. Cages and runways are kept clean and airy and are sterilized at regular intervals. Food is especially prepared for them in diet kitchens, from which recently has come much of our knowledge of the all essential vitamin contents of our foods. Before most operations they are anæsthetized and if to be sacrificed are killed painlessly. After operations their care is as important in the result of the work as is the operation itself. The affection that develops between a dog that has been experimented on and his surgeon is sufficient evidence of the lack of cruelty.

But what can be said of the cruelty of the persons who seek to hamper medical progress which promises a still greater saving of life, greater prolongation of the life span, and greater relief of suffering by placing restrictions and hindrances about those who are devoting themselves to human and animal welfare?